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Art in the Botanical Sciences

10 years
Applications in Plant Sciences
Celebrating 10 years 2013-2023

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FROM the EDITOR

Greetings,

I am thrilled to share this very special issue of *PSB* that focuses on the many connections between science and art. This issue has been brought to you by an impressive team of guest editors: Patricia Chan, Rosemary Glos, Ashley Hamersma, Kasey Pham, and Nicolette Sipperly. I want to thank this team for their creative visioning and hard work putting this issue together. I also want to thank the talented authors and creators who have shared their work with us. There was such a positive response to the call for articles on this topic that we anticipate continuing this subject in our Spring and Summer issues.

In this issue, you will also find many of our regular *PSB* sections, as well as news and awards from Botany 2023 and profiles of our new Distinguished Fellows.

Sincerely,

Mackenzie

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SPECIAL SECTION

Art in the Botanical Sciences: Past, Present, and Future

As you may have guessed from the cover, this is no ordinary issue of the *PSB*! You are reading the first in a multiple-issue anthology dedicated to art and the botanical sciences. We, your guest editors, are a group of graduate students from four universities who are passionate about the intersections of botany, art, and personal expression. This anthology grew out of our first workshop on botanical art at Botany 2022 in Anchorage, AK. As artist-scientists, we have worked to create spaces where our colleagues can discuss their complex, and sometimes challenging, experiences of bridging the gap between disciplines. The *PSB* editorial team invited us to expand on the ideas shared in our workshop via a special issue. We accepted with enthusiasm and set to work soliciting abstracts for an issue that celebrated the many ways that people integrate art and botany. We received so many exciting proposals that the resulting pieces will be published in three(!) consecutive issues of the *PSB*.

In this issue, you will learn about a variety of artist-scientist collaborations, integrations of art and science in museums, scientists' and artists' accounts of what drives their curiosity and exploration, and the role of art in teaching and herbarium curation.

In preparing this issue, we learned that "anthology" comes from the Greek anthologéō, or "I gather flowers." How fitting for a collection of works that celebrate the beauty and wonder of the botanical world. We hope the pieces featured in this anthology inspire you to envision how creativity can enrich our lives as scientists, artists, and educators.

Enjoy!

The SciArt Collective

Nicolette Sipperly, Stony Brook University

Rosemary Glos, University of Michigan

Kasey Pham, University of Florida

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Weaving Together Culture and Ecology to Express My Identity as a Scientist

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ABSTRACT

To reach broader audiences, science communication must move towards imaginative and unconventional methods of conveying research and knowledge. I use embroidery to weave together my personal, scientific, and cultural experiences and share them with not only other scientists but general audiences and my family. I grew up helping my grandparents forage for medicinal plants, weed their crop fields, and herd our family cattle every summer in the grasslands of Mexico. Our daily work required knowledge of when and where plants grow, when to harvest, and when to rotate cattle. Despite my exposure to botany and ecology at an early age, I never linked my family's cultural knowledge to these fields of science. The more I researched about my Mexican heritage, the more proof I found of various ways to transfer knowledge via cultural practices. Traditional embroidery has long been a way for people to record the plants and animals that were present on the land, as well as an important way to share important stories and lessons. As a scientist, I integrate my culture into my work by using embroidery to communicate my research, study species, and express my identity through art. This form of transferring knowledge also helps promote cultural diversity and inclusivity in science. Given that information is conveyed mainly through visualizations rather than text via embroidery and other art forms, SciArt also removes language barriers that may prevent individuals from engaging with science. Although I use embroidery here as an example of expressing my identity as a scientist, I encourage others to find ways to express their science using other forms of media (e.g., sculpture, dance, song) that provide creative avenues for passing knowledge from one generation to the next.

I was fortunate to spend my childhood summers in the semi-arid grasslands of Zacatecas, Mexico with my grandparents. Surrounded by a diverse range of flora and stunning exposed cliffs, I was captivated. My grandparents taught me the importance of being land stewards, showing me how to rotate cattle to ensure plant regrowth the following year and how to identify and use plants with ethnobotanical properties. These were all lessons that had been passed down orally for generations in my family. Although I was not consciously aware of it at the time, these experiences were integral to developing my scientific worldview, but I would not begin to link my family's cultural knowledge to scientific concepts in ecology until college. This realization allowed me to self-reflect on my identity and explore other forms of transferring knowledge in Mexican culture that I may have overlooked. I was captivated by the use of artisan's hand embroidery to convey stories and even record flora and fauna that were present on landscapes through beautiful images created on textiles using colorful threads. Today, I am continuing this tradition by using embroidery to communicate my science with broader audiences, express my identity as a Mexican-American scientist, and weave together my scientific training and heritage in hopes of encouraging the representation of cultural diversity and knowledge in science.

As a first-generation Mexican-American, I wanted to fit in with my peers, and sometimes fitting in came at the cost of suppressing my own Mexican heritage. My mother started to teach me how to embroider when I was 10, showing me the various stitching techniques my great-grandmother had taught her. As a child, I was eager to learn how to use stitches to display intricate flowers, birds, and mammals. But as I entered my teenage years, I spent less time practicing my embroidery until I stopped altogether to make time for other hobbies that I could share with my American friends. I had also stopped making my annual trips to Mexico due to heavy cartel violence that was rampant at the time. This change meant that I could no longer engage in ranching, farming, or family gatherings in Mexico—activities that had always been a central part of my life. Consequently, this led to an identity crisis where I found myself identifying more with my American companions and losing the firm grip I had on my Mexican roots.

During my college years, I wasn't entirely sure about my cultural identity, but I knew for certain that I wanted to become a scientist to solve the environmental concerns plaguing our world. My understanding of science was limited to the Western perspective, where trained scientists collected data and validated it through peer review. However, it wasn't until I took an undergraduate ecology course that I realized how much my grandparents' traditional practices were rooted in the fields of community and restoration ecology. It was foolish of me to not recognize earlier that their knowledge of rangelands and natural resource management was science. Their ecological knowledge was accumulated over generations of trial and error, and this realization encouraged me to reflect on my identities. In turn, I found a creative outlet through SciArt embroidery to express my cultural ties and share science.

My first attempt at merging science and art via embroidery was unsuccessful. I had forgotten how technical the work of embroidery was, and my work was riddled with crooked stitches and tension issues throughout. Although it wasn't pretty, I wanted to show my grandma that I had finally found a way to share my love for science while paying homage to my Mexican roots. After ten years of not seeing my family in Mexico, I made the journey to reconnect, share my work, and seek advice on how to fix my technique. My grandma and my aunts gave me pointers on how to improve my technique, but also expressed joy that "the young generation is keeping our tradition alive." My mother was especially proud of me for embracing my Mexican heritage within academic spaces, because she had witnessed my struggles with identity for years. This trip inspired me to design a series of hoops to convey important concepts and processes within the field of plant ecology.

Given my scientific interests, plant invasions are a common theme in my SciArt. For instance, stinknet, a focal species of my dissertation, is an invasive plant that is difficult to manage due to its prolific seed production and persistent soil seed bank (Figure 1A). Likewise, I created a hoop that shows how the dispersal of introduced grasses into a community can establish an invasive grass-fire feedback loop by increasing biomass and fuel continuity while suppressing native plant recovery (Figure 1B).

A large reason why I feel comfortable expressing myself within academic spaces is due to my advisor's support, Dr. Larios, who is a fellow first-

Figure 1. *Embroidery hoops showing (A) stinknet (*Oncosiphon pilulifer*) accumulating seeds in the seed bank, and included a harvester ant (*Pogonomyrmex rugosus*) crawling along the soil surface to depict a collaborative study investigating the role of harvester ants in dispersing invasive plants, and (B) invasive grass-fire cycle that establishes once invasive grasses disperse into a community, which creates a litter layer that adds fuel and connectivity that carries fire easily and creates a feedback loop to maintain invader dominance while suppressing native recovery.*

generation Mexican-American, and an incredible scientist. To show my appreciation for her dedication to creating an inclusive workspace, I designed and embroidered a hoop to represent the various research topics (e.g., trophic interactions, coexistence and land management) she studies throughout California (Figure 2). One of my favorite things about embroidery is the removal of a language barrier. One can stare at a hoop and recognize the heterogenous landscape of California, along with the biodiversity of plant species, herbivores (e.g., cows, kangaroo rats) and fire on the landscape hinting at ecological processes.

Figure 2. *A 12-inch embroidery hoop I made for my PhD advisor, Dr. Larios, to showcase the wide scope of her community and restoration ecology research program in California, which was established in 2017.*

SciArt is a powerful tool for self-expression and knowledge transfer that can reach broader audiences and increase inclusivity in science. For many individuals who come from historically underrepresented groups within the fields of STEM, this is a way for us to help integrate forms of cultural knowledge and dissemination into a Western-dominated society. Peer-reviewed journals are already recognizing the power of art to convey information by requiring graphical abstracts (i.e., visual representations of the article's main findings). Although I use embroidery here, I encourage others to find their own artistic outlet to promote their science and help them share their story. I urge my colleagues to try out visual and performing arts to discover their preferred creative outlet. Above all, do not hesitate to take the first steps toward integrating art with botanical sciences, whether that means making the initial brush stroke, threading the first needle, or collaborating with an artist.

Art in the Herbarium?

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In the 1980s, only one species of the genus *Anisotes* was known in Madagascar. However, a specimen on loan to the California Academy of Sciences (CAS) from the National Museum of Natural History in Paris seemed to be from the same genus but with distinctive leaf and flower shape. Daniel Thomas of the CAS wanted to know more, so he asked botanical illustrator Erin Hunt to draw the plant from the specimen. The result was different from what he expected, but Hunt thought she had captured the form correctly. When CAS botanists went to Madagascar with the drawing in hand, they found the plant, identifiable from the drawing. Hunt had been right (Daniel et al., 2007).

Such stories are rather common in botany. After the illustrator Patricia Fawcett at Fairchild Botanical Garden drew a flower from life with too many floral parts to fit the taxon description, botanists realized intra-species variation required amending the description (Stevenson and Stevenson 2014). Conceptualizing a given species can involve several different kinds of input ideally including fresh and preserved material, but also hand-drawn illustrations. The emergence of modern botany in the 16th century was based on this assumption, which required the rejection of classical authorities' deep distrust of hand-drawn illustrations (Reeds, 1976). It is not surprising that Luca Ghini (d. 1556), the director of the first botanic garden in Pisa, was a very early proponent of herbaria and field trips as well as a collector of drawings and printed artwork, some from the first printed herbals with good illustrations (Findlen, 2017). It quickly became common for botanists to trade or borrow both specimens and images, as they moved away from reliance on classical authorities who distrusted plant drawings.

The Swiss naturalist Felix Platter (1536-1614) arranged his bound collection so that in many cases he would have one or more images on the left-hand page, and a specimen of the same species on the right (Figure 1; Benkert, 2016). On the other hand, the Italian naturalist Ulisse Aldrovandi (1522-1605) stored his specimens and watercolors separately. Some early modern botanists used other visual technologies including nature prints and rubbings to get information about plants into a portable reference format. There were even some who painted in missing parts of a specimen. Because botanical terminology was in its infancy, visual representations could differentiate among similar species in ways that written descriptions

Figure 1. *From Felix Platter's herbarium (volume 7, pp. 86-87). Hand-colored woodcut image of common bean (*Phaseolus vulgaris*) from the German edition of Leonhard Fuchs's 1542 herbal, facing specimen of the same species. Courtesy of Bern City Library.*

could not. Those interested in plants preferred to receive drawings rather than text. Some argue that it was the illustrations that pushed botanists to write descriptions of equal clarity, and that the artists of the age were influential in causing botanists to observe more closely (Smith, 2003).

The relationship between drawing and knowing has become a topic of interest among historians of art and science. The astronomer Omar Nasim (2013) describes how repeated drawing of nebulae in the 19th century clarified the concept of an astronomical phenomenon that, as its name suggests, was blurry. As more observations were made, as drawings were repeated night after night, these hazy structures become more familiar to the observer's eye, mind, and hand. Drawings were tools in the process of discovery and knowledge stabilization. In drawing, the hand slows down observation, allowing the mind to synthesize. Barbara Wittmann (2013) reports on a scientific illustrator's experiences working on a new fish species where getting the drawings correct led him to discover novel anatomical features. Botanists who choose to do at least their own preliminary drawings have similar experiences. As they draw plant structures repeatedly, often from different perspectives or from different dissections, they find themselves learning more and having to correct their drawings and written descriptions along the way.

If a professional illustrator is doing artwork, there is a back-and-forth, with the botanist making corrections. This is what Lorraine Daston and Peter Galison (2007) term "four-eyed sight," producing a more informative image than one pair of eyes could. Clarity and discovery arise from this give-and-take. A drawing helps both the botanist and the audience to understand more about the plant. The zoologist and illustrator Jonathan Kingdon (2011) appeals to research on the neurophysiology of sight to explain why pen and ink drawings and prints are particularly useful. The human brain processes signals from the eyes by detecting edges and accentuating them. This means that black-and-white illustrations communicate information especially effectively because they are in tune with the brain's visual processing system.

As more and more new plants were discovered around the world beginning in the 1500s, botanists were challenged with naming and describing them. There was a fervor among many to publish new species as soon as possible, often based only on specimens or drawings sent to them. Even Carl Linnaeus described many species solely on the basis of watercolors or printed black-and-white illustrations. When his species descriptions were later typified, these images became lectotypes since they were the only materials he had examined. This was true for other botanists as well, although now the practice is only allowed in defined cases in the International Code of Botanical Nomenclature for Algae, Fungi, and Plants (Turland and Wiersema, 2018).

Pragmatically, drawings of plants also serve as a back-up to specimens and descriptions. The plants of New Spain that were collected in the late 18th century by the Sessé and Mociño Expedition reached Spain safely, but their analysis and publication was disrupted by Martin de Sessé's death and the Napoleonic Wars. José Mociño fled to France, taking with him some written descriptions and nearly 2000 illustrations made during the expedition. In Montpellier, he shared this hoard of information on undescribed species with Augustin Pyramus de Candolle, who was writing a comprehensive work on the world's plants. De Candolle regarded these watercolors and sketches as so valuable that he had them hastily copied by a large team of artists before Mociño returned to Barcelona. After Mociño's death there, the originals were lost until 1979! Consequently, for more than 150 years, de Candolle's annotated copies became the primary source of information about hundreds of New World species (McVaugh, 1998).

In the 18th and 19th centuries, British colonial administrators in India created botanical gardens as a way to gather and observe many species to find those that could be sources of food, medicines, and useful items such as textiles and timber wood. Meanwhile, botanists collected thousands of specimens in support of this effort. It became standard practice to have Indian artists paint watercolors of many of these plants. This was not just to have a record of a plant's color and form, but also to ensure that there was any record at all. In tropical climates, conditions sometimes drove collectors to rely on nature prints and drawings. It was difficult to preserve specimens in hot humid areas and to prevent insect and fungal damage.

In the 20th century there were botanists like Oakes Ames at Harvard who included ink drawings and watercolor sketches by his artist wife Blanche Ames on his orchid specimens. This approach continues as drawings of flower dissections and microscope enlargements of structures are added to sheets by botanists and artists. Because of the importance of having different kinds of information about a plant available at the same time, such practices persist, but there has been a change in storage practices. In the past, illustrations of a species were often stored in the same folder as specimens of that species. This was handy for botanists but perhaps not so good for the art, which could be damaged by substances leaching from the plants. With the start of digitization projects, when folders that hadn't received attention for years were examined, it became common to remove the illustrations, particularly if they weren't physically attached to the specimens. They are now usually stored separately, often in the library or archives affiliated with the herbarium.

The Royal Botanic Garden Edinburgh (RGBE) has a large number of Indian plant specimens, many collected by physicians who had trained in Edinburgh and later served Britain's massive colonial enterprise in India. Henry Noltie, then a curator at the RBGE herbarium, spent months going through folders, removing the images created by Indian artists and successfully re-sorting them from taxonomic order into separate collections, many donated by one person or organization and in some cases created by a single Indian artist or by a small group. Noltie was often able to identify the artists by name, but others remain anonymous. Through this work, Noltie learned a great deal about the collections and the people related to them, producing several books on these works (Noltie, 2002, 2017). The art is now stored in the RBGE archives, along with correspondence and other papers from those responsible for the specimen and art collections. The Royal Botanic Gardens Kew and many other institutions have done the same.

This policy makes the illustrations more available to those interested in the historical and artistic significance of these works and keeps them together as collections so they can be compared in terms of style. In other words, the images are now treated more as works of art than of science, perhaps to the detriment of science. What might be good for the botanical art and for the history of art and botany, might not be the best solution for botanical inquiry. Past collectors of Indian botanical art were often as interested in them as works of art as of science, and today this is true for many who collect botanical art. However, both the art and specimens were created as scientific documents, whether or not they had any obvious aesthetic appeal. The botanist Peter Crane (2013) considers botanical illustration as important today as it was hundreds of years ago, but notes economics has changed the picture. Today, color images are rare in taxonomic treatments of new species, and even pen-and-ink illustrations are less prevalent, even though, for all the reasons discussed earlier, illustrations can provide vital information to botanists.

The works described here were created as adjuncts to specimens, living and preserved, and they should be able to continue to function this way. Opening up a species folder and finding illustrations can provide a botanist with information on color and form less likely to be documented in the specimen itself, thus making it easier to create a full mental image of the plant. If the illustrations are stored elsewhere, this richness is lacking. A trip to the archives would be necessary to see the relevant drawings. Since some of the art collections have been digitized, and herbaria are continuing to digitize their collections, it should be possible to link a specimen to one or more illustrations of that specimen as one facet of the extended specimen concept.

Implementing such an idea is hardly trivial. The databases used in science and those for art and archival materials are often quite different. There are moves toward standardization across platforms, but implementation will not be easy. The work of developing what is called FAIR data—Findable, Accessible, Interoperable, and Reusable—is substantial (Manzano and Julier, 2021). The colonial origin of a good deal of both types of collections needs to be acknowledged as well. However, my focus here is on the value of linking art to science, an important component since the 16th century. It is as important today not only for what botanists can learn about plants but for the aesthetic lift that comes with examining these works, even if the goal is to seek out taxonomic information. The botanist Richard Mabey's (2015) comment is relevant here: "The quintessence of a plant can only ever be a fantastic goal, something to travel towards but never reach" (p. 27). That's why we need to dig into—and preserve—different types of information: living plants, specimens, art, and photography, which should not be forgotten but is outside the scope of this article.

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The Significance of Illustrations as Nomenclatural Types in Botany: "Iconotypes" at the Natural History Museum Vienna, and the Importance of Color Systems, Such as Those Utilized by Ferdinand Bauer [1760–1826]

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ABSTRACT

Aside from the more commonly selected herbarium specimens for this purpose, a botanical illustration—in particular, a historical one—can also serve as type for the name of a taxon. The Archive for the History of Science at the Natural History Museum Vienna holds many such "iconotypes." These include illustrations used in Jacquin's, Schott's, and others' taxon descriptions. Additional drawings of great value for taxonomy are annotated field sketches, such as those by Ferdinand Lukas Bauer. The field drawings, often with locality data and dates of observation, enabled him to produce colored plates of exceptional aesthetic and scientific quality by employing numerical and other codes to document color, hue, brightness, opacity, and texture of morphological features.

KEYWORDS

Australia, Linnaeus, natural history collections, New Holland, Norfolk Island, nomenclature, typification

HISTORICAL ILLUSTRATIONS AS NOMENCLATURAL TYPES FOR PLANT NAMES

Although the term "iconotype" is not formally used in the International Code of Nomenclature for Algae, Fungi, and Plants (ICN), it is generally understood to be an illustration that serves as the type for the name of a taxon. For example, the lectotypes of many Linnaean binomials in botany and zoology are illustrations (Jarvis, 2007, 2008). When a type specimen is lost or destroyed, illustrations prepared from the original material can be candidates for types; such illustrations are obligate lectotypes when all other original material has been lost.

"Iconotypes" at the Natural History Museum Vienna Archive

The Archive for the History of Science at the Natural History Museum Vienna (NHMW) houses a significant collection of historical illustrations, some of which are types for names of animals, fungi, and plants (for example, illustrations by Nikolaus von Jacquin [1727–1817], Joseph Franz von Jacquin [1766–1839], and Heinrich Schott [1794–1865]).

Most of Schott's specimens of Araceae were destroyed in a fire at the end of WWII (see Riedl, 1981) so that taxonomists (e.g., Coelho, 2000) have to rely on Schott's illustrations of original material for typification (Figure 1). Other examples are mycological illustrations in Jacquin (1776), as few, if any, of Jacquin's specimens of fungi have survived; for example, the published illustration of *Boletus cinnabarinus* Jacq. (= *Pycnoporus cinnabarinus* (Jacq.) P.Karst., Polyporaceae) is the type (see link in References).

Figure 1. *Note that this figure can only be accessed electronically via https://doi.org/10.5281/zenodo.7874857. The lectotype for* Philodendron imperiale *Schott, a synonym of* Philodendron ornatum *Schott (Araceae), 'Schott Aroideae' No. 3620 (see arrowhead). Most of Schott's specimens were destroyed in a fire at the end of WWII, and taxonomists use the illustrations of original material commissioned by Schott (this one done by W. Liepoldt, double arrowhead) for typification.*

One Step Beyond: The Field Drawings of Ferdinand Lucas Bauer

Use of illustrations as types is facilitated if they were made using standardized coloration. An outstanding example of this is the work of Ferdinand Lucas Bauer (FLB), whose pencil field-sketches, now almost all at NHMW, were the bases for colored illustrations (mostly now at BM), some of which are types. The drawings are important, because they include information omitted from the final, colored illustrations, such as collection localities, dates, and additional detailed sketches of descriptive morphological characters (Mabberley, 2021). The sketches also bear FLB's notations using numerical and other codes, which indicate the hue, brightness, opacity, and texture of particular parts of the living organism (Figure 2). FLB did this to document rapidly the coloration of a specimen in the field with a view to his "reviving" this later in watercolor.

FLB's drawings recorded for the first time many Australian species then new to Western science, as he accompanied Matthew Flinders' voyage (1801–1803), the first documented circumnavigation of the continent. For example, Figure 2 shows an as-yet-undescribed species of *Thomasia*, a genus restricted to Australia (Malvaceae). This is likely *T.* sp. Vasse (Wilkins and Shepherd, 2019; but see Shepherd and Wilkins, in preparation). Exceptionally, the notation on the drawing indicates that FLB drew it at Kew Gardens, where the plant was raised from seed, most likely collected during the expedition.

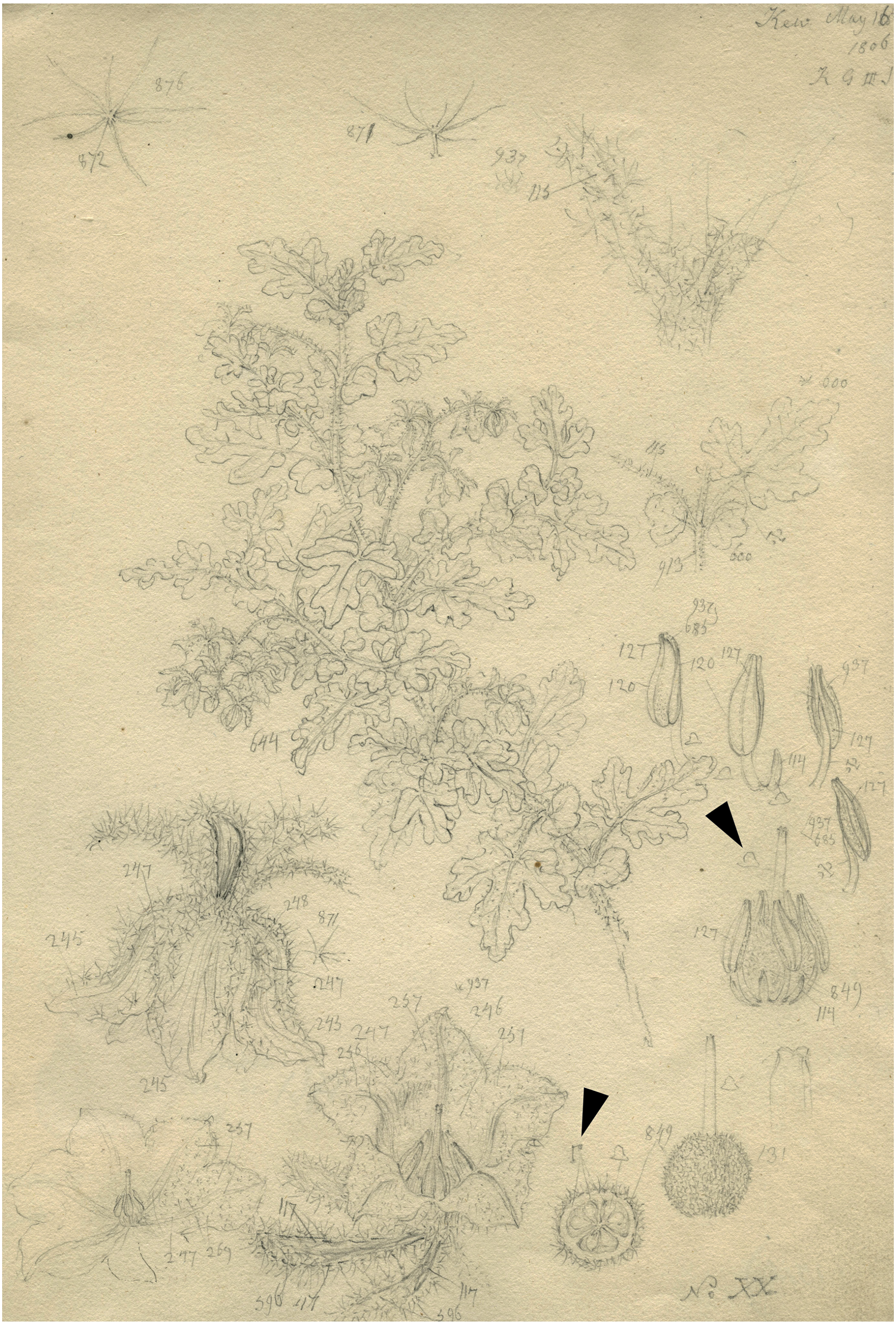

Figure 2. *Drawing by Ferdinand Lucas Bauer of an undescribed species of* Thomasia *currently listed as* T. *sp. Vasse (Malvaceae). Note that the numbers on the drawing correspond to numerical codes Bauer used to indicate hue, brightness, opacity, and texture of a particular structure. The arrows point to additional symbols, such as sigils.*

Color Charts for Standardization in Historical Illustration as Used by Bauer

FLB used the "painting by numbers" technique throughout his career (Mabberley, 2017). His color-code evolved over time and could have been derived from principles in, or partial use of, color systems developed by others. These include Brenner (1680); Estner (1794), which is specifically referenced on some of FLB's Pacific drawings (Mabberley, 2017, 2019); Schäffer (1769); Schiffermüller and Denis (1771); Struve (1797); Werner (1774); Widenmann (1794); Willdenow (1799); and, perhaps, that associated with Haenke (see Lack and Ibáñez Montoya, 2004, but also Mabberley and San Pío Aldarén, 2012). FLB may also have utilized color tables used by various tradespeople (ceramics painters, printers, tanners) and chemists (Pörner, 1773; Gülich 1779, 1780, 1781, 1786). Over time, he used an increasing range of numbers, and the later work, in Australia, included values close to 1000 (Pignatti-Wikus et al., 2000) for botanical subjects, and beyond in the later zoological drawings made on Norfolk Island. However, FLB's elaborate color chart is lost (Riedl-Dorn and Riedl, 2019), if it ever existed (Mabberley and San Pío Aldarén 2012; Mabberley, 2017, 2019, 2022; Jelley, 2022). Jelley (2022) has a practical explanation for the numerical code based on an art practitioner's process, showing that the layout of FLB's paintbox may have functioned as his aide-memoire and that the numbers could have been a two-part code. The first one or two digits specified which pigment to use, and the last digit(s) were directions on how to achieve the correct blend, brightness, opacity, etc. In other words, if this hypothesis is proved, there probably never was a physical color-chart of FLB's.

In addition to numbers, FLB used many additional ciphers, especially in his later zoological drawings. These include planetary symbols to convey information about color, in that they were then commonly understood to correspond to metals such as gold for the sun (☉), silver for the moon (☾), and so on. However, FLB sometimes also wrote the actual words "gold" or "silver" on drawings together with the symbols. We assume therefore, that the symbols had additional meaning and may also refer to particular color blends, pattern, texture, brightness, and/or opacity for that color (e.g., yellow for ☉). Bauer also used upper- and lower-case letters, maybe corresponding to those in the tables of Schiffermüller and Denis (1771), but also see Pignatti-Wikus et al. (2000), sigils (symbols used in alchemy and magic; see Figure 2), and the Greek alphabet. Roman numerals usually indicate the number of any particular structure (e.g., stamens in a flower, spines of a fish fin). It is currently mostly unclear, though, what these additional symbols exactly mean. Jelley (pers. comm.) is conducting further research into these more complex layers of information in FLB's Australian work.

The importance of Ferdinand Bauer's drawings at the NHMW to taxonomic biology, as "iconotypes" and otherwise, is only now beginning to become clear. A thorough investigation of the collections, necessarily involving international collaboration, is much needed (Mabberley, 2021). In addition to their immeasurable scientific and aesthetic value, these drawings document the Australian flora largely before European settlement. It would therefore be important to make them available to a broader audience. This will require funding for a collaboration between Australian botanists, NHMW staff (archive, botany, and library), and to hire project-based digitization staff.

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DATA AVAILABILITY STATEMENT

High-resolution scans of the illustrations shown and other "iconotypes" are available upon request for research purposes via the Archive for the History of Science at the Natural History Museum Vienna (archiv@nhm-wien.ac.at).

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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AUTHORSHIP

S.F.: review and editing (equal); M.K.: review and editing (equal); D.J.M.: conceptualization (equal), writing – review and editing (supporting); H.R.: review and editing (equal); M.-D.R.: conceptualization (equal), writing – review and editing (supporting), figure preparation (lead); T.M.S.: conceptualization (equal), writing – original draft (lead), writing – review and editing (lead), figure preparation (supporting).

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Celebrating the Launch of the UTEP Virtual Herbarium by Highlighting Contemporary and Historical Art and Science of the El Paso Region

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As archives of historical plant specimens, herbaria provide snapshots of environmental landscapes across time that are continuously accessed, recontextualized, and reinterpreted through modern techniques. Moreover, specimen imaging in herbaria has been key to recent global digitization efforts that confer multiple benefits, including facilitating taxonomic revisions and enabling better access to biodiversity data (Soltis, 2017). Specimens also become discoverable to non-traditional researchers, such as artists and the interested public.

From 2019 to 2022, the University of Texas at El Paso (UTEP) herbarium imaged and georeferenced all its specimens (~50,000 records) from the southwest US and Mexico, funded by two grants (IMLS IGSM-245733 and NSF DBI1902078). To celebrate these projects, largely conducted by biology undergraduates, we developed the exhibit "Where We Will Grow: Elsie Slater, Plants, and Art" at UTEP's Centennial Museum and Chihuahuan Desert Gardens (Fall 2021–Spring 2022) to showcase the history, art, and science of the herbarium. We chose to highlight Elsie Slater (1871–1952), a self-taught botanist, because her collections represented the earliest specimens from El Paso held by our herbarium and because her unique dual interests in both the arts and the sciences. Slater was a writer and artist whose works are held at UTEP (Centennial Museum and C. L. Sonnichsen Special Collections), which span the scientific (exceptional botanical art) to the impressionistic. Drawing from Elsie's diverse interests, the UTEP Herbarium partnered with the Art Department's Drawing I Class taught by Nabil Gonzalez to use specimens from Elsie's collections as inspiration for student art. Because of COVID-19 restrictions, art students visited the new digital herbarium (Project Page: https://arctos.database.museum/project/10003615) rather than the physical herbarium. Collections Manager Vicky Zhuang met with the students via Zoom during a class period to introduce the project. She described the herbarium, provided examples of how researchers used herbarium specimens, and guided the students through how to use the database to find images of specimens. Students were then instructed by Nabil to reinterpret Elsie's point of view towards the botanical world and the romance of life. Each student researched their chosen specimens and subsequently created a composition representing a page out of a journal. The students were asked to restrict their search to the El Paso area and to focus on Elsie's collections when possible. However, they were intentionally not exposed to Elsie's artworks, so they would be inspired to develop their ideas independently and with few limitations. With regards to the exhibit, students were only told that their pieces would be paired with Elsie's works and specimens in a botany

Figure 1. *Botanical-inspired art and science exhibited during the "Where We Will Grow Exhibit." (A) A portion of the exhibit pairing student art pieces with a description of Elsie Slater and her works, specimens, and art; (B) an example of Elsie's art pieces; (C) a* Porophyllum scoparium *specimen (UTEP 6646) used as art inspiration in part D; (D) art piece by Julyet Carillo, using several species (UTEP 6646, 6696, 6649) showcased in the exhibit; (E) tour stop at the purple prickly pear (*Opuntia macrocentra*) in the gardens, connecting living specimens to Elsie's specimen (UTEP 6668). Photos courtesy of the Centennial Museum (A and B).*

and art-focused exhibit and were encouraged to explore a variety of mixed media and concepts.

This project granted students the experience of Elsie's creative world that blended botany and art. For example, Elsie's specimen sheets often had poetic notes. When describing a Baileya multiradiata (UTEP 6602), she noted, "…one of the brightest gold flowers, very very beautiful for our city." Digital collections allowed students to thoroughly examine these specimens by focusing on shape, form, color, and texture. Artists take inspiration from nature and the world around them (Flannery, 2013). Everything they see, touch, and feel is an important part of how artists understand and research the creative process. Thus, the collaboration gave art students a new perspective on the artistry of scientific specimens through Elsie's unique collection.

Because students were not restricted in style, the students produced art pieces that represented a diverse range of interpretations, realistic to abstract, sometimes of the same specimens (Figure 1). However, additional check-ins to ensure the accuracy of scientific names and species associations would have been beneficial. Despite working independently, some students converged on similar motifs (i.e., eyes, bones, life, and death). Additionally, like some of Elsie's botanical art, some of the pieces included text (i.e., Figure 1B and D), as well as true-to-life reflections of the specimens. Several art students found relief from the pandemic lockdown and discovered new inspiration in their local plant diversity. Finally, biology students curating the exhibit connected to the specimens they had been working on in a new and broader context. Overall, the exhibit revealed parallels in modern perspectives of science and art using historical specimens.

The resulting exhibit, "Where We Will Grow: Elsie Slater, Plants, and Art," combined Elsie's botanical specimens, art, and writings with diverse pieces of contemporary student art. Curators selected specimens from Elsie's collections that were used by students, represented in Elsie's art or both (i.e., Figure 1C and D). To draw cohesion with the exhibit and living plants, patrons toured the museum's Chihuahuan Desert Gardens via a self-guided tour app that linked living and herbarium specimens. To choose the stops, we cross referenced a list of specimens used by the art students and species represented by Elsie's collections to species available in the Centennial Gardens (i.e., Figure 1D and E). At each stop, patrons scanned a QR code and viewed a specimen collected by Elsie, its locality information, and a few facts about the species. As a result, patrons could view the same species in multiple contexts, from the past, present, and future, through art, as well as historical and living specimens.

The digital exhibit can be accessed at https://www.utep.edu/centennial-museum/museum/past-exhibits/where-we-will-grow.html.

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From the *PSB* Special Issue on Art in the Botanical Sciences

Celebrating Plant Diversity through Art

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ABSTRACT

Especially in recent decades, plant scientists have had to develop new skill sets, becoming statisticians, bioinformaticians, evolutionary ecologists, visual artists, as well as experts in many fields of biology. In regard to visual arts, botanists have a long history of collecting plant specimens for herbariums across the globe to showcase plant diversity and through illustrations, they raise awareness of the vast ecological importance of plants in their diverse habitats. With botanical art, plant scientists increase the public appreciation of plant diversity and provide access to diversity in regions where some of these plants had never been seen. Now, with huge online repositories of digital plant pictures, DNA/RNA sequencing, ChIP-seq, metabolomics, and proteomic/crystallography data, plant scientists have increased the ways to catalog plant diversity at the molecular level, and further increased the access of these resources to fellow scientists. In this series of illustrations, and through a modern digital twist of botanical art, we hope to celebrate the progress made by plant scientists around the world to accelerate our understanding of plant evolution and diversity and highlight a promising avenue for scientific illustration to play a role in depicting fundamental plant biological concepts and molecular diversity.

KEYWORDS

botanists, plant diversity, plant scientists, science art

New technologies, such as DNA/RNA sequencing, ChIP-seq, metabolite profiling, X-ray crystallography, and others, have expanded our methods for cataloging plant diversity by allowing scientists to study plants at the molecular level. In Figure 1, we celebrate the novel and impactful efforts made by plant scientists to catalog plant diversity across scales—from proteins to *Petunias*. Understanding the diverse interactions occurring at the molecular, cellular, organismal, and environmental levels accelerates our understanding of plant diversity and adaptation to their environments.

Next to the chromatin, mRNA transcripts are being subjected to RNA interference (F). At the top is an homage to the petunia experiment where RNAi was first discovered (G). Some of these transcripts, however, can be transcribed by ribosomes and become proteins (H). Many proteins interact at the cellular level and work together to carry out

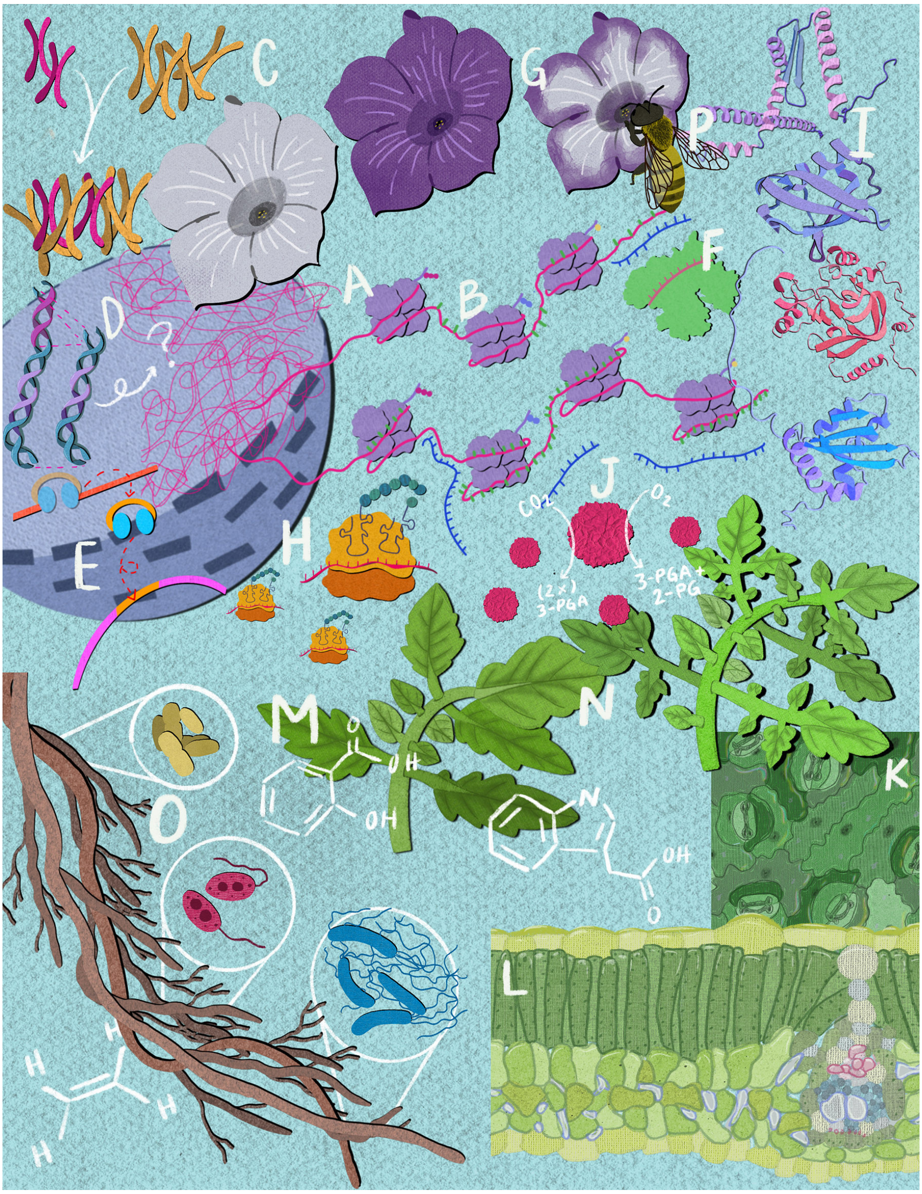

Figure 1. *Several discoveries have revealed how plants interact and respond to their environment. See the text of this article for further explanation.*

a wide range of biological functions, including transcription, translation, signaling, metabolic processes (I), and carbon fixation (J).

On a larger scale, we see how cell types that have differential gene expression patterns and vary in protein populations can come together to form tissues, such as in the stomata-epidermal cell layer (K) and the leaf cross-section (L). These cells interact with each other to communicate with themselves and the environment to respond to stimuli they might encounter.

Plants can respond to hormones such as auxin, ethylene, and salicylic acid (M), which play a crucial role in the diverse interactions occurring within and between plants. Hormones regulate plant growth, development, and response to environmental and pathogen stress.

On the bottom, we see variation in tomato leaf shape with age, known as heteroblasty (N). A subset of phenotypic variation of developmental traits allows plants to adapt and interact with their environment differently, potentially providing an advantage in various ecological niches depending on the circumstances.

In addition to interacting with their abiotic environment, plants interact with other organisms. Understanding the interactions of plants with other organisms such as microbes (O) or pollinators (P) is critical for understanding the role of plants in their ecosystem.

Continuing to catalog plant diversity at the molecular, cellular, and environmental levels is crucial to understanding and appreciating how plants interact with their environment, furthering our understanding of how plants have contributed to the diversity of life, and accelerating efforts to conserve plant species in a rapidly changing world.

Brazilian Botanists Flirting with Arts: Valuing the Multicultural Heritage

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Plants have always been a source of inspiration for many artists, and Botany often resorts to them so that plants "live" eternally—as is expected—in artistic works. And the plants, what can they "tell" us about these humans who try to understand them using Science and Art? Brazilian literature brings rich examples in which plants are the protagonists (see Clarice Lispector or Ana Martins Marques). In the book *O pensamento vegetal: a literatura e as plantas* ("Plant thought: literature and plants" in free translation), Evando Nascimento, a Brazilian writer, highlighted the relationship between literary text and the floristic universe at the 19th International Literary Festival of Paraty (Flip). In this edition, the focus was on "Nhe'éry," the Atlantic Forest as named by the Guarani, one of the many native peoples of Brazil.

Initiatives focusing on this powerful Art–Botany relationship are still germinating in Brazil (following "ArtScience Manifesto"; see Bernstein et al., 2011), with some botanists and teachers building upon the multisensory and poetic experience created by plants and the world. It is clear that, even though sparsely distributed throughout Brazilian history, there have been other non-scientific artistic initiatives between art and plants. But here, we present some of the Art and Botany (as a science) initiatives and, especially, contextualize the complex cultural interplay that shaped these two areas in Brazil.

COLONIAL HERITAGE

The arrival of Europeans represented a breaking point in how art was seen and produced in Brazil. However, there is a rich recorded Brazilian Pre-Cabraline Art (in reference to the Portuguese navigator Pedro Álvares Cabral, the "discoverer" of Brazil), represented by cave painting, sculptures, and ceramics. Amazonian ceramics are probably the best-known artistic manifestations of Brazilian Pre-Cabraline Art (Prous, 2007). Prior to colonial contact, Indigenous art was sovereign; subsequently, other cultures, especially from the African continent, also set out their point of view. The art of the remaining Indigenous peoples is still quite expressive in Brazil (for more, see examples of Carmézia Emiliano and Uýra Sodoma). The presence of artists (e.g., Thomas Ender and Johann

Moritz Rugendas) in the field expeditions to the interior of Brazil showed the European vision of the Brazilian flora, and everyday aspects for the original people took on grandiose dimensions for those who were unfamiliar with it.

Botany assumed the status of *Scientia Amabilis* at the end of colonial period in Brazil, when the knowledge about plants was seen as an important social status with reverberations in architecture, in gardens, and in the great scientific expeditions to recognize the flora and the associated biodiversity. National Botany Day in Brazil celebrates the birthday of a Bavarian naturalist, Carl Friedrich von Martius. Although this symbolic date highlights how the European view is still hegemonic in Brazilian Botany, it is impossible to ignore the tremendous value of Martius' legacy. Together with Johann Baptist von Spix, Martius traveled immense distances through Brazil between 1817 and 1820 throughout a variety of domains and recorded all the floristic diversity they encountered in the magnificent *Flora Brasiliensis* compendia. They returned to Europe with a huge collection of preserved biological samples and live specimens. Two young Indigenous people from different ethnicities in Brazil, Miranha and Juri, were also taken to Europe and died some time later. The story of how those people were integrated into Martius and Spix's expedition is still controversial and has more than one version (Costa, 2019). At the end of his life, Martius rejected the brutal behavior of including people as collectibles, which was sadly common among colonizing naturalists. Martius and Spix produced valuable ethnographic descriptions, and the masks collected by them in Amazonia are an important record of symbolic practices by Indigenous nations, many of them now extinct (Santos, 2014).

Gradually, not only was European culture brought to Brazil, but also species in vivo or in graphic representations, such as those that adorn the Portuguese tiles, or *azulejos*, of northeastern Brazil (Menezes et al., 2020). In this case, it was up to Brazilians to appreciate the Europeans' paintings of non-native plants without the feeling of cultural identity (belonging) about the artifact or what it represented (Silva et al., 2021).

Brazilian flora began to be included slowly in art as part of sacred works and sculptures (e.g., Machado et al., 2018). At that time, art in general was closely linked to Catholic productions, and much of what was produced had underlying tendencies. In this sense, a devaluation of the arts produced by cultural groups that existed in Brazil (such as that by Indigenous people) or that were brought to Brazil (such as by Africans) was inevitable, since until then these local groups did not share the Christian faith. Although the quality and historical value contained in the Portuguese *azulejos* and sacred sculptures are invaluable, the presence of plants is linked to the technical character, as part of the work, and not as something to be felt (Figure 1).

Contrary to the visual arts, music and dance had already been impacted by the presence of different cultures on Brazilian land. Orality carried out information about plants from north to south of the country. For example, in Samba or Capoeira (a dance/fight created by Brazilians of African descent) songs, the use of native plants in the production of percussive instruments and rituals is common (Hartmann et al., 2023). The fact is that, although the Brazilian population of the colonial period was composed of many people—it is important to highlight that Indigenous and Africans were composed of countless different ethnic groups, and each one had its own way of seeing art and plants—the contribution for "botany and art" was unbalanced.

Decolonization Movements

In 1922, a great artistic exhibition called "Semana de Arte Moderna (SAM)" took place in São Paulo. Organized by artists and intellectuals, the movement suggested breaking up with artistic European traditions of the time. SAM is

Figure 1. *(A) Integration between Botanists and Designers to create new prints for "azulejos" in Maranhão using native species (an "azulejo" of babaçu [Attlaea speciosa Mart. ex Spreng.]; see Silva et al., 2021). (B) Artwork detail of the exhibition "Weavings of life - Art and Botany," at Science and Technology Park of the University of São Paulo (described by Ursi et al., 2023). (C) Short course offered by Moraes and Portugal on the representation of botany in works of art of Brazilian modernism and its possibilities of use in teaching. In these materials, there is the possibility of educational work on: monocultures, different land uses and environmental degradation, capitalist mode of production, exclusion of socially minority groups, and the production of paints from coffee fruits and these products. (D) Natureza-morta (1868; Agostinho José da Mota). Painting used in a guidebook of daily plants (Marcelo G. Santos, 2023 in press) to discuss native and exotic fruit. Photo in (B) by T. Cesquim.*

considered a symbolic reference of the beginning of Brazilian Modernism period. One of the works that had a great impact on its configuration was the *Manifesto Antropofágico,* published in 1928 by Oswald de Andrade. The document proposes a process of swallowing European ideas, techniques, and cultural thoughts to transform them, without being submissive, but critical, in the promotion of Brazilian art in essence (Ajzenberg, 2012). The representations of Brazilian flora in modernist productions are vast and present the great Brazilian biodiversity. Ribeiro (2020) reports the mention of more than 200 plant species in these works of art. In her book, she discusses 19 of these plants, such as banana, cactus, corn, coffee, and Brazil wood. Moraes and Portugal (2021) reflect on the use of some of these species in teaching processes from a decolonial perspective.

Although it has great importance in the country's historical and cultural scene, Brazilian Modernism is not marked as a genuine Brazilian movement. In the 1920s, the coffee-growing elite (known to be former enslaved peoples' owners) financed SAM. The art movement was built by and for the Brazilian elite, without considering the knowledge and cultures of other populations living in a country as large and diverse as Brazil.

Less prominent than SAM, the *Movimento Armorial* (MA) was a relevant artistic initiative for the appreciation of popular knowledge. MA started in 1970 and was led by playwright and writer Ariano Suassuna (1927–2014). The movement aimed to produce an authentic Brazilian art that is erudite but rooted in Brazilian popular culture. The movement guided the convergence of artistic expressions to produce a national art, having the northeastern region of Brazil as a source of inspiration. In these productions, the Caatinga domain was portrayed amidst the experiences of its people. Such initiative arises from the need to value local productions and northeastern scenarios, in which the great biological and social diversity of the Caatinga is highly valued.

The counterpoint to this thought is the production of *Literatura de Cordel* (LC), which uses popular language with rhymes and verses that present metric perfection. Despite its colonial heritage, LC is an artistic expression intimately linked to the Brazilian northeast. LC portrays the knowledge and experiences of the people of the Northeast. LC, rich in images produced through woodcut and use of a clothesline for its public exhibition, highlights Brazilianness. Because of this, it is used as a didactic tool by several educators, including in the teaching of Botany. For more on LC and Botany, see Oliveira and Cavalcante (2020) and Santos et al. (2022).

Embrionary Botany Art Initiatives

From the Martius expedition until now, some Brazilian botanists seek to reconnect *Scientia Amabilis* with art, but from a new perspective, valuing the diversity of environments, cultures, ethnicities, and regional characteristics (Figure 1).

These efforts of botanists in Brazil to merge plants and art have been successful. However, they are still stuck in a utilitarian metric—always trying to answer "what is this for?"—that underuses the driving force of art. We have a long way to go to a ScienceArt expression that promotes diversity, but starting this conversation is the first step to walk this path.

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Integrating Botany, History, Culture, and Contemporary Art in a Botanical Garden Museum

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Botanical gardens create a unique opportunity to intersect science, culture, and art to offer interdisciplinary experiences for the public. The Missouri Botanical Garden's historic (ca. 1859) Botanical Museum was restored, renovated, and renamed the Stephen and Peter Sachs Museum and reopened to the public in late April 2018 after more than a century of alternate use. As the Museum Curator and sole staff member responsible for the Sachs Museum, I curate exhibitions using botanical science as the focus of the exhibition narrative, interweaving history, material culture, and inclusive perspectives, together with commissions of contemporary site-specific work. As a part of the Science & Research Division at the Garden, the Sachs Museum collaborates with departments managing other plant-based collections, including the Herbarium (dried plant specimens) and the William Brown Center's biocultural (ethnobotany) collection, to feature the important work Garden staff is doing in botanical science.

Visitors to the Missouri Botanical Garden come from a spectrum of backgrounds—some are well-versed in botany and horticulture, but many are not. The challenge is to engage these publics on the myriad ways plants are relevant to our lives, yet also include the botanical science that the Garden experts work on daily in St. Louis and around the world. I focus on subjects that embrace the ubiquity of plants, so that visitors enjoy the rediscovery of plants on a subject previously overlooked. The foundation of the exhibition subject is on botany (and horticulture and entomology when relevant); this topic might feature in Garden research or have a universal impact and appeal. Where possible, I include little-known connections from other disciplines and collaborate with other science and community organizations, museums, and lenders to highlight information that might impact visitors on a personal level, such as regional history or material culture. Finally, I commission contemporary artists to create artworks that interpret the botanical subject in unique and meaningful ways to expand understanding about the subject. The two most recent exhibitions at the Sachs Museum embodied the key goals I am trying to achieve with this multidisciplinary framework. I also create live in-person programs as well as digital content for exhibitions for both education and promotion; this includes musical performances, virtual tours, multiple blog posts, myriad social media posts on X (Twitter) and Instagram, and talk series highlighting the art and science connections.

To celebrate Missouri's bicentennial of statehood in 2021, I planned an exhibition to focus on a Missouri viticultural innovation with deep roots in the botanical history of the state and long-lasting impacts on viniculture around the world. The exhibition intertwined this history with contemporary scientific research investigating this innovation through several site-specific artworks focused on the grapevines using contemporary media of film and machine learning. *Grafting the Grape: American Grapevine Rootstock in Missouri and the World* explored the millennia-long human cultivation of wine from the grapes of *Vitis vinifera* as a drink for social, religious, and economic power. The native American grape species that were used historically by the Indigenous peoples of North America were also used in the viticulture of early colonial Missouri, and continue in the state's wine industry today. In order to address a global insect infestation in the 1860s, Missouri scientists and horticulturists grafted these native rootstocks with the *Vitis vinifera* grape scion, thereby enabling the survival of the wine grape. Without the research and innovation by 19th-century Missouri botanists, entomologists, and viticulturists, drinking wine from this species would not be possible today. Artist Dornith Doherty—renowned for her photographic work on seeds and global seed-banking—created photographs and two short films for her series *Roundabout (Circuition)* inspired by the intersection of the historical innovation and the contemporary scientific research taking place in Dr. Allison Miller's NSF-funded Vitis Underground project (exploring the impact of different rootstock species on the grafted grape berry). Artist collaborators inspired by the impact of climate change on grapevines, Lei Han and Lorraine Walsh focused their work for *Grafting the Grape* on environmental shifts as seen through the seemingly disparate practices of ancient horticultural grafting techniques and contemporaneous machine learning (a subset of artificial intelligence). Their art focused on the native grapevine species Missouri *Vitis aestivalis* (also known as Missouri's Norton grape) and the process of this mediation in order to bring a fruitful awareness of the significant effect climatic change has on life. They created drawings, digital images, and three short films for the exhibition, as well as a large sculpture titled *The In-Between* (Figure 1). This stylized wooden trellis held two horizontal rows of five plexiglass plates each, with the upper row featuring engraved drawings of the grapevines and the lower row engraved with drawings of the rootstocks; the negative space in-between the plexiglass plates is where the grafting occurs, and the viewer's imagination fills in the blank. Visitor feedback consistently was one of awe; for the beauty and character of the artworks on display, but also for the global impact of this integral innovation that is still relevant today.

Figure 1. The In-Between, *abstract grafted grapevine sculpture, by Lei Han and Lorraine Walsh, 6'6"L x 1.5"D x 8'9"H, ca. 2021. (Photo credit: Virginia Harold)*

The 2022 exhibition *Botanical Resonance: Plants and Sounds in the Garden* embraced how important plants are in the human soundscape—both in nature and culture—and how these species are endangered globally due to overharvesting and climate change. A particular focus included how the Garden is working with scientists and musical instrument makers around the world to address some of these conservation issues. In conversation, visitors and other curators continually remarked on how they were previously unaware of how dependent humans are on plants to create sound and music. A series of live music performances featuring plant-based instruments, such as alphorns and west African idiophones, gave opportunities to experience (hear, feel, sense) the vibrations of sound making in person. I commissioned three contemporary artists to create artworks interpreting plants and sounds in different ways. Annika Kappner created two auditory guided soundwalks (accessed via QR code) that provided a meditative exploration of plants and sounds into the Garden. Brooke Erin Goldstein designed a full gallery quilted room installation visualizing the ways plant families communicate with one another, in which the world is bisected, above and below (Figure 2). As pictured, one half of the gallery featured a forest's underground root system network, and the other half illustrated a manicured yard of grass that had just been cut, visualizing the grass screaming (we usually experience this as the smell of cut grass). Kevin Harris composed and built an electronically synthesized immersive rainforest sound installation as an offering to the botanical world that nourishes us every day. A virtual talk series with the artists gave detailed presentations on the creative process for the artworks in the exhibition.

Figure 2. Reverberations, *an immersive quilted room installation by Brooke Erin Goldstein, 26'4"L x 19'10"D x 8'4"H, ca. 2022. (Photo credit: Virginia Harold)*

Curating exhibitions to intersect plant science, human culture, and art expands the possibilities of interpretation for the public, opening up avenues of engagement that make botanical content relevant for many visitors who might be intimidated by science-only content. While anecdotal and not quantitative, feedback from my conversations with the public and other curatorial colleagues has made clear that approaching a subject of popular interest—while including botanical science and art—makes an impact on how people understand (and enjoy learning about) how connected plants are to our lives. These experiences remove barriers to information and build connections that will lead to deeper understanding of plants, as well as the larger world around us.

Science, Art, and the Allure of Photographs

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The raw form of scientific data is usually unfamiliar to a general audience. One exception to this are photographs. Lenses and cameras are common tools in scientific, artistic, and popular use, and the photograph represents a rare example of a shared medium across these contexts. For the scientist, a photograph is raw data (e.g., a scanning electron micrograph of pollen grains on a stigmatic surface or an *in situ* hybridization assay of gene expression in a developing leaf). For the artist, though, a photograph is an expressive object produced by their creative work. In both cases, the photograph is a visual record of a lens pointed at a subject, regardless of whether the primary intention is analytical or aesthetic. This is a remarkable confluence of two different approaches to learning about the world (science and art) that are often regarded as wholly distinct fields. Here, we explore the photograph and the cultural intersection between science and art, asking what consequences and opportunities arise from the shared practice of lens-based image-making across these two disciplines.

Science and art are both concerned with producing insightful observations of the world. Hand lenses, microscopes, and cameras augment how we see—focusing, enlarging, or warping a visual field. Our view through the lens represents the world in a way that reminds us of our natural perception but may be impossible to achieve through unaided sight. However, lenses do not generate an image from nothing. Rather, they project only and exactly what the photographer frames in front of them. We say that photographs are *taken*—images plucked directly from the fabric of reality. Recognizing this, we imbue photographs with an objective authority over the *truth* not granted to other visual media. "More convincingly than any other kind of picture, a photograph evokes the tangible presence of reality. Its most fundamental use and broadest acceptance has been as a substitute for the subject itself—a simpler, more permanent, more clearly visible version of the plain fact" (Szarkowski, 1966). For artists, this makes photography unique from other visual media, such as drawing and painting. For scientists, this means that photographs can be regarded as trustworthy primary data.

It is important to recognize that the status of photographs as objects of truth has been abused since the early days of the medium. We do, after all, have photographic "evidence" of the Loch Ness Monster, Bigfoot, and the Cottingley Fairies.

Digital technologies like Photoshop and generative Artificial Intelligence further complicate the photograph's reputation for objective truth-telling. Furthermore, our belief that cameras are objective recording devices may lead us to downplay the influence of a photographer's biases and agendas, which are expressed in a series of decisions about composition, focus, and moment of capture. Yet, our fundamental trust in photography endures, even if it is now, more than ever, accompanied by a healthy dose of skepticism.

Plants are particularly well-suited to photographic observation because they do not move. In fact, the first two books to be illustrated by early photographic techniques both featured images of plants. One of the pioneering women in botany, Anna Atkins, created *Photographs of British Algae: Cyanotype Impressions* (1843), which was entirely devoted to plant subjects, and the 24 photographs in William Henry Fox Talbot's *The Pencil of Nature* (1844) are primarily of architectural subjects with the organic exceptions "Leaf of a Plant" and "A Fruit Piece." We can also look to plants for an early example of the power of photography in the scientific record. In 1912, botanist Dr. Norma Etta Pfeiffer discovered a miniscule plant growing within the city limits of Chicago, which was then the second largest city in the United States. She described this plant as a new species, *Thismia americana*, recognizing that it belonged to a genus of small mycoheterotrophic flowering plants that had not been observed in North America before (or since). Unfortunately, this plant has not been found since 1916 and is presumed extinct due to habitat loss. So how can we be sure that such an unlikely plant even existed? Indeed, the possibility of a botanical hoax devised by Dr. Pfeiffer has been raised (see Wilhelm and Rericha, 2018). However, in addition to Dr. Pfeiffer's reputation as an excellent botanist and plant morphologist, the *T. americana* story is believed in part because she took and published photographs of the plant in 1914 (Figure 1; Pfeiffer, 1914). The suspicion of a hoax would likely be much stronger had Dr. Pfeiffer chosen to publish drawings of the plant instead of photographs.

Figure 1. *Norma Etta Pfeiffer's photographs of* Thismia americana *published in 1914. These images confirm the existence of this species, now thought to be extinct. (Images in the public domain.)*

Today, photography (still or moving) is a primary mode of visual communication. The medium is a democratic one—most people make and/or consume photographs every day. Due to the ubiquity of photographs and their relationship with *the truth*, looking at a photograph is an intuitive way for an audience to learn about the reality of the world. This suggests that photography-based platforms like most social media have enormous educational potential (provided that the content is unaltered and accompanied by credible interpretation; Figure 2). The global popularity of these platforms (exceeding 1 billion users) attests to the ability of photography to grab our attention and hold it. A photograph is memorable,

Figure 2. *A soon-to-emerge leaf of* Liriodendron tulipifera *is visible through large enclosing stipules. Visually arresting photographs are powerful teaching tools when accompanied by expert interpretation. This image was originally posted to Instagram (@letsbotanize). (Photograph by Jacob Suissa.)*

expressive, and persuasive with minimal barriers to engagement for broad audiences. Photography is, therefore, one of the most powerful tools available to educators, artists, and scholars aiming to communicate credible information with large audiences because it is both an aesthetically engaging and data-rich medium.

The accessibility of photo-taking has also made possible a tool like iNaturalist, which crowdsources "research-grade" photographic data at a global scale. The iNaturalist image database has been used to train machine learning algorithms that attempt to identify organisms through the live camera feed of a smartphone. Interestingly, the capabilities of such algorithms are determined by (and reveal) trends and biases, including the way photos of other species are composed, which phenological stages tend to warrant photographing, which populations use iNaturalist, and which habitats are easily accessed by humans. These biases occur regardless of which angles, features, and habitats would be most taxonomically useful. For instance, details of the bud and leaf scar are very useful in distinguishing among species in the hickory family (Juglandaceae), but rarely warrant the photographic attention of non-botanists. In theory, such biases and gaps should only diminish over time as more images are added to the training dataset. iNaturalist takes advantage of the photograph's dual identity as an object of beauty and an object of data to engage broad audiences in the practice of research.

As science communicators, we are particularly excited about the unique potential of photography to provoke curiosity and excitement about the natural world. John Szarkowski describes photographers as recognizing that "the world itself is an artist of incomparable inventiveness" and "the compelling clarity with which a photograph recorded the trivial suggested that the subject had never before been properly seen, that it was in fact perhaps *not* trivial, but filled with undiscovered meaning" (Szarkowski, 1966). Everything in frame and in focus is recorded with equal fidelity by a camera. Take a photo outside, and the unfathomable complexity of the natural world is all there at a level of intricate detail that a human mind could never generate from scratch; the only limit is the resolution of the photograph. Plants especially benefit from this feature of photography, since unlike people, cameras do not experience plant awareness disparity (Parsley, 2020). Because plant life dominates terrestrial biomass, most photographs of "nature scenes" will contain plants (likely in abundance). Inevitably, bird photography, snake photography, and insect photography are also plant photography, even if the photographer themself only considered the plant life as patches of green to be balanced within the composition. Fortunately for the botanist or the plant-focused science communicator, those plants lay in wait within the frame, ready to be discovered as anything but trivial. The medium of photography itself incites a sense of awe and curiosity and a spark to explore the image in search of beautiful moments. These are exactly the emotions that science communicators hope to inspire in their audience.

The photograph is both scientific and artistic; composing and recording an image through a lens is one instance in which the two practices coalesce. Both endeavors value photography's capacity for creating information-dense and captivating records of reality. Whether deployed in science, art, or in braiding the two together, photography wields enormous potential for learning and communicating about the world. Through photography, science communication has the capacity to reach larger audiences than ever on visual-driven social media platforms. At the same time, deploying photography for scientific research or education must be accompanied by a deep sense of responsibility to not abuse our intuitive trust of the medium.

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Filling Out PhyloPic: Call for Adoption by Plant Scientists


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ABSTRACT

PhyloPic is a crowd-funded database of organism silhouette images that currently contains 8364 accepted submissions from 585 volunteers. Each silhouette image is associated with a taxonomic name via a network of phylogenetic nodes, enabling dynamic searches based on evolutionary relationships. The project has become an invaluable artistic resource for scientific publications, with more than 1900 references in published articles. Despite its success, adoption and contribution by plant scientists has been relatively low. Only ~8% of current submissions are for organisms within *Archaeplastida* (*Plantae* sensu lato), representing just ~0.066% of named terminal phylogenetic nodes (i.e., species or subspecies). To further improve the utility of PhyloPic and promote increased use across the plant sciences, we showcase fast and efficient methods for creating suitable silhouettes from multiple image sources including photographs, illustrations, and herbarium specimens. These methods will help increase adoption and quality of submitted images and complements the recent release of PhyloPic 2.0, which features faster performance, an improved user interface, and automatic conversion of submissions to infinitely scalable vector files.

KEYWORDS

creative commons, figure creation, open access, PhyloPic, scientific communication, silhouette images

Creating impactful figures to effectively communicate science is challenging. Many scientists aspire to create educational and inspiring figures but struggle due to a lack of artistic skills or limited access to high-quality graphics. These barriers can be eased through expansion of the PhyloPic platform.

PhyloPic is an open database of free silhouette images of organisms. Each silhouette is associated with taxonomic names via a curated phylogeny drawn from a variety of sources, primarily The Open Tree of Life (OpenTreeofLife et al., 2019) and The Paleobiology Database (McClennen et al., 2017). This enables dynamic searches based on phylogenetic relationships, either manually through the website (https://phylopic.org) or programmatically, through a public Application Programming Interface (API; https://www.phylopic.org/articles/api-recipes) or the R package (Gearty et al., 2023). Despite the PhyloPic platform being written in English, the binomial nomenclature used for searching the website is universal and enables use of the platform regardless of a user's language. Website users can also create collections of silhouettes that can be used to create permanent links for attribution. The "Collections Drawer" tool enables users to create named sets of silhouettes for later use. Collections are private and stored in the user's browser cache, but they can be turned into permanent shareable links.

Currently, PhyloPic features 8364 accepted submissions from 585 volunteers. The project has become an invaluable artistic resource for scientific publications, with more than 1900 references in published articles. However, plant taxa are noticeably underrepresented on PhyloPic, with only 669 silhouettes, making up just ~8% of all contributions. For comparison, there are 1552 dinosaur silhouettes (~18.6% of contributions). Single images often represent extremely large and variable clades like *Austrobaileyales* and *Pandanales*. Even for groups with multiple silhouettes, there is usually only a single silhouette per species. With this article, we hope to demonstrate methods that can be used by plant scientists to help expand the collection of plant silhouettes and showcase the morphological variability, plasticity, and growth stages of plants.

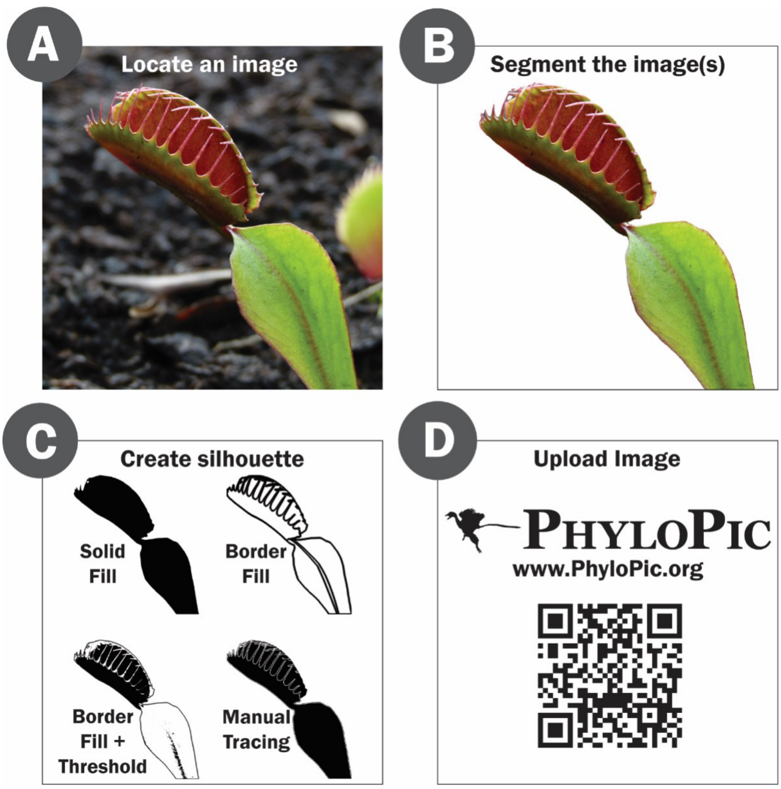

Figure 1. *Suggested silhouette creation pipeline. (A) Locate a freely useable and suitable image. Online search platforms include Creative Commons Openverse, iDigBio.org, Global Biodiversity Information Facility (GBIF), Google Image Search, Symbiota Portals, and Wikimedia Commons. (B) Segment the image to remove background and undesired parts. Programs include ImageJ, ImageJ2, Fiji, Ilastik, and Meta AI Segment Anything. (C) Create a silhouette. The four silhouettes depicted are all suitable for upload to PhyloPic and show different approaches to silhouette creation. Programs include Adobe Illustrator, Inkscape, Adobe Photoshop, ImageJ, ImageJ2, and Fiji. (D) Upload the resulting silhouette(s) to PhyloPic.org (contribute.phylopic.org). Programs and online search platforms mentioned are suggestions by the authors and not an exhaustive list of available options. Original image of* Dionaea muscipula *by Michal Klajban, CC BY-SA 3.0 via Wikimedia Commons.*

Methods

While finding images that can be used to make a silhouette is relatively simple, it is important to use personal images, images in the public domain, or images with permissive licenses (e.g., Creative Commons). Tools and sites like Creative Commons Openverse (https://search.creativecommons.org/), Wikimedia Commons (https://commons.wikimedia.org/wiki/Main_Page), Google Image Search, iDigBio (https://www.idigbio.org/), Global Biodiversity Information Facility (GBIF; https://www.gbif.org/), or Symbiota Portals (SEINet [e.g., https://swbiodiversity.org/seinet/], SERNEC [https://sernecportal.org/portal/], TORCH [https://portal.torcherbaria.org/portal/index.php]) can be used to identify suitable starting images. Creating silhouettes that can be submitted to PhyloPic from these images is a straightforward process with multiple programs and methods available (Figure 1). Open-source and freely available programs used by current contributors include Fiji (ImageJ), Inkscape, Ilastik, and SegmentAnything (Schindelin et al., 2012; Schneider et al., 2012; Rueden et al., 2017; Berg et al., 2019; Inkscape Project, 2023; Kirillov et al., 2023). Commercially distributed tools that can be used to create silhouettes include Adobe Photoshop and Adobe Illustrator (Adobe Inc., 2023a, 2023b).

Creating a simple, solid black silhouette begins with image segmentation but can end in a variety of methods. In segmentation, the pixels that make up an image are grouped together into individual objects based on a defined criterion. Tools for segmentation vary in their ability to detect complex detail, but greater detail in segmentation typically requires either significant user input or a more powerful program. New web-based approaches, like Meta's Segment Anything are particularly helpful for individual images whereas software like Ilastik can be used for batch processing of similar images. Once an image has been segmented, there are many different methods for silhouette creation including but not limited to border filling, solid filling, thresholding, manual tracing, as well as combinations of these techniques. We have created multiple instructional videos showcasing a variety of methods for silhouette creation and have generally outlined the process and provided examples of optimal silhouettes and a sample use of PhyloPic silhouettes (Figures 1 and 2).

PhyloPic is accessible to users through email-based registration. Once registered, users may submit image files using a chat-like interface via the Contribute Tool (https://contribute.phylopic.org) as they are guided through three main steps:

1. Uploading an image file and optionally converting to a scalable vector graphic (SVG)

2. Identifying the specific taxon represented by the image

3. Selecting a Creative Commons license for the image

Uploaded files go through a manual review to ensure they accurately depict the organism. To minimize rejections, file size should be limited to 5 Mb with submissions being a minimum of 1536 pixels wide or tall. Acceptable file types include PNG, GIF, BMP, JPEG, or SVG and should be solid, pure black (#000000) on a white (#FFFFFF) or transparent background. Each silhouette should clearly show the entire organism or a specific, recognizable part of it (e.g., a leaf). To increase the utility of the linked taxonomic search, users should be as precise as possible when identifying taxonomy during submission, with species being the preferred level.

Submissions are reviewed by the site curator. Once approved, each silhouette is published on the website in a variety of sizes and formats. The graphics available on PhyloPic can be downloaded directly from the website, via the public API, or into R through the rphylopic package (Gearty et al., 2023).

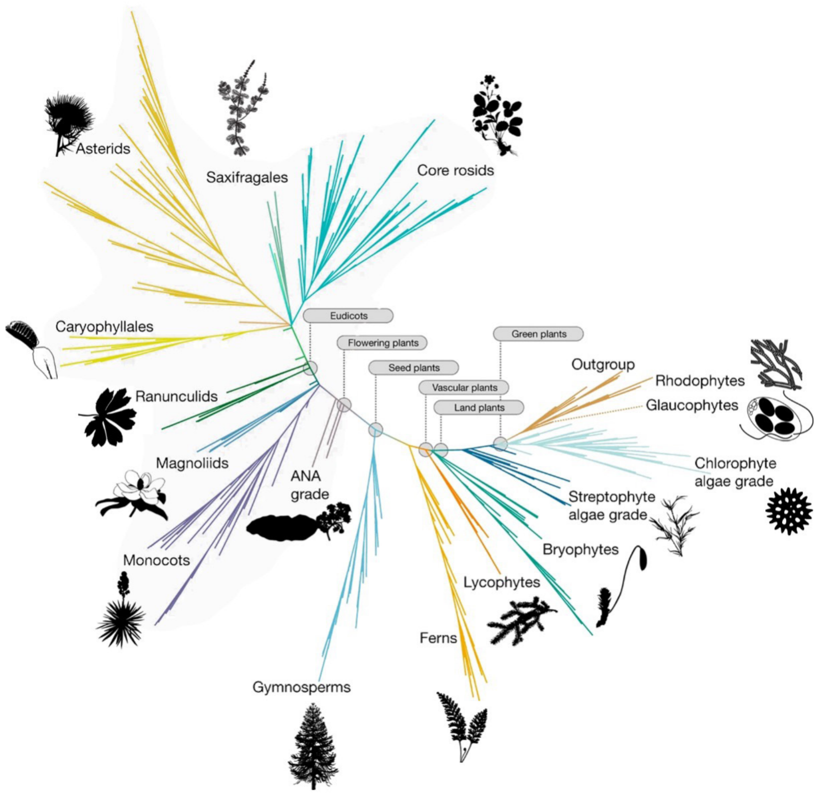

Figure 2. *A sample figure adapted from "One thousand plant transcriptomes and the phylogenomics of green plants" (Leebens-Mack et al., 2019) with silhouettes from PhyloPic added. Silhouettes downloaded from PhyloPic: https://www.phylopic.org/collections/a7844e00-c254-07de-0137-ccb687820a6d*

Discussion

Scientific figures can quickly and concisely communicate detailed information, but without clear visual landmarks, they can be impenetrable. In biology, silhouettes are an easy way to instantly convey taxa to other scientists and the public. PhyloPic's phylogenetic organization and open API make it simple to find and use relevant silhouettes for a given taxon. All silhouettes on PhyloPic are hosted under Creative Commons licenses in the public domain (PDM), CC0 (requires no credit given), or as CC BY (requires credit given to the author). It is up to the end-user to properly credit silhouette authors and PhyloPic when necessary.

To assist with the creation of silhouettes, PhyloPic has a "Silhouette Sponsorship" program (https://phylopic.org/sponsorship), where users can commit to creating silhouettes for their chosen taxon or donate to PhyloPic to request taxa to be added. Requested taxa are placed on a publicly accessible priority list that allows volunteer contributors to prioritize silhouette creation. However, creating a silhouette of your chosen organism following our how-to videos (Figure 1) is the most efficient option.

PhyloPic affords plant scientists the opportunity to use free silhouettes on statistical charts, biogeographic maps, cladograms, and other data visualizations. However, plants are currently under-represented in PhyloPic, limiting the potential of this community-led tool. For perspective, if every member of the Botanical Society of America (n ≈ 3000, 2023) contributed just one silhouette, there would be nearly five times as many available plant silhouettes. With the submission process recently re-engineered and streamlined, we encourage everyone to contribute to this valuable community resource.

AUTHOR CONTRIBUTIONS

M.M.: Conceptualization, Methodology, Data Curation, Writing, Visualization, Supervision, Project Administration; **M.K.** Conceptualization, Methodology, Validation, Resources, Writing

DATA AVAILABILITY STATEMENT

All how-to videos and data used in this paper are freely available on the Open Science Framework repository (doi.org/10.17605/OSF.IO/JBUW5), on PhyloPic.org, or by request from the corresponding author.

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Can the Collaboration of Science and Art Broaden Our Understanding of Nature?

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Humans transform, filter, break down, and reassemble seemingly endless amounts of information as we make sense of the world we live in. For an ecologist observing a natural ecosystem, this process may produce a graphical figure summarizing a targeted property of the system to understand the consequences of environmental change; for an artist observing the same phenomenon, this may result in the formal use of abstraction, form, and color as an inquiry into the ways humans interface with "Nature." If viewed only in this way. the two disciplines emerge as a simple dichotomy; yet in reality, the two have many approaches in common, both of which help us understand the world we live in. Since 2014, the two of us (a scientist who studies the ecological interactions among of plants and animals, and a visual artist utilizing video and digital media) have been collaborating at the intellectual confluence of the sciences and arts with the goal of generating novel perspectives on the world that surrounds us and our relationships to it. In this paper, we discuss our long-term, ongoing collaborations at the intersection of science and art, how it can influence our individual perspectives by building trust and exchange between scientists and artists, and how such collaborations have the potential to create new ways of knowing and understanding. To explore these ideas, together we created Figure 1: a creative appropriation of video still's taken from Dorf's (2021) film, *A New Nature*, that was predominantly produced and conceptualized during the 2021 field season at the Rocky Mountain Biological Laboratory. Throughout the film, the viewer is provoked to consider not only the future of what Western culture commonly refers to as "Nature" in the face of a changing planet, but also what the term itself means in contemporary life and language. Figure 1 functions as an illustration of the work produced from our long-standing collaboration, as well as a visual tool and metaphor to better understand the ways in which we collaborate.

Ways of Seeing Nature

Taking influence from John Berger's *Ways of Seeing* (1972), we begin by asking the question: when observing nature, what is it that we see and why do we see it in that way? This question sits at the center of our collaboration as scientist and artist and is one that we are continually investigating. Figure 1A presents an image that can feel both familiar and foreign. Recognizable elements of a spruce forest can be identified on a localized scale: needle-like leaves, tree trunks, color palette, and variation in light. But when zooming out to see

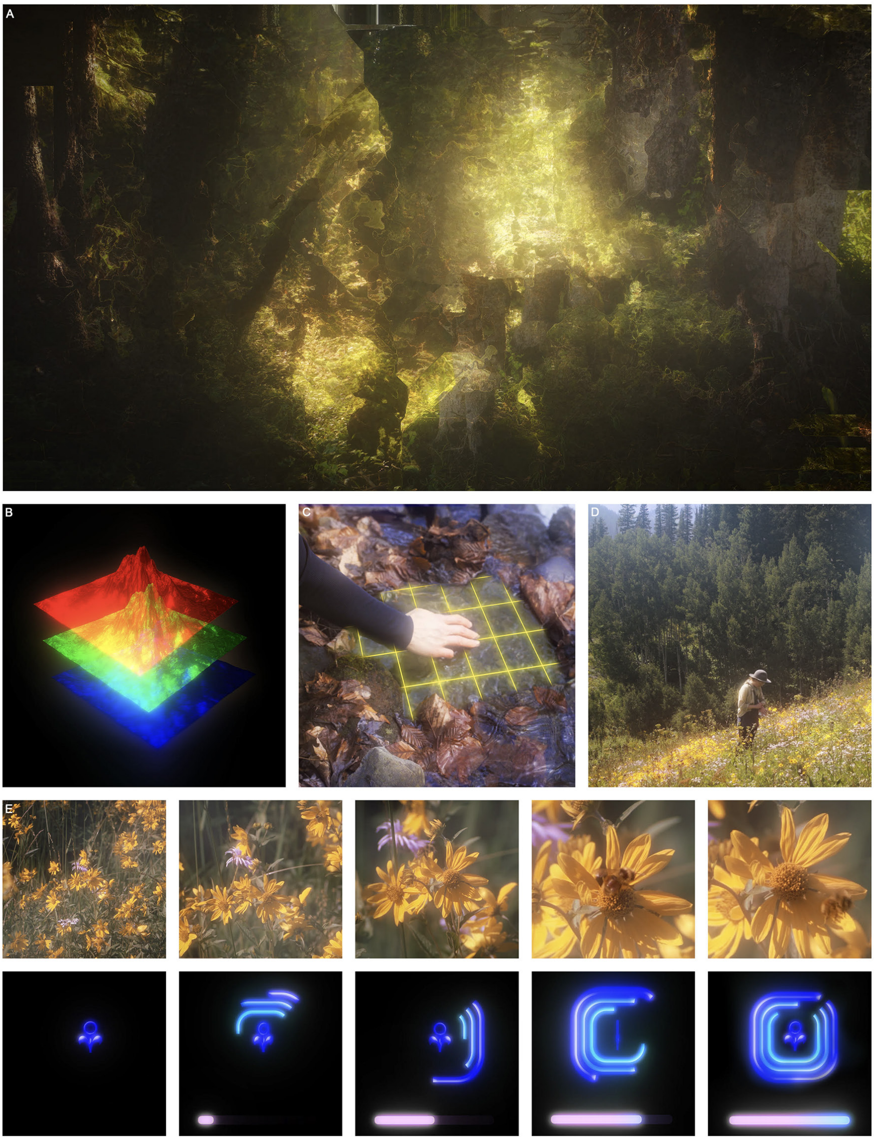

Figure 1. *An illustration of the work produced from the bidirectional collaboration between science and art as a visual tool and metaphor of the collaboration and how we understand nature. We created this figure together in Dorf's art studio in New York City and then later at CaraDonna's lab at a remote biological field station in Colorado (The Rocky Mountain Biological Laboratory). (A) Digital collage image of subalpine spruce forests. (B) Digital image of three identical 3D-rendered mountains split into the additive color channels of red, green, and blue. (C) Digital image of a hand reaching into a small pool of water that has a grid atop its surface. (D) A scientist in a subalpine meadow noting the timing of an observation of a pollinator visiting a plant. (E) Two series of five images illustrating the passing of time building up to a discrete event. All still images are from the film,* A New Nature *(Dorf, 2021).*

the entire image, these familiar elements and the logic of the image and the forest itself fall apart. We have something that appears and feels like a forest, while simultaneously approaching nonsense. In other words, Figure 1A asks us to ponder: how can we recognize this image of a forest when there is in fact no forest represented; or, put another way, how do we understand something as it changes rapidly in real time? This idea is analogous to how, as we begin to understand many dimensions of ecological systems for the first time, they are simultaneously shifting in response to global change.

As we consider this tension in our observation and perception of nature, we turn to Figure 1B, which investigates how we filter, transform, split, and rearrange our observations as we try and make sense of them. In Dorf's (2021) film, *A New Nature*, the form featured in Figure 1B rotates, undulates, and slowly separates as the voiceover asks: "Tell me what you see. Can you tell me what I see? What is there in front of you?" The voice over and rotating landscape are directly inspired by Piaget's (1954) experiments with early childhood development and object permanence in which Piaget would present a model landscape to a child, ask them to describe the scene, turn the landscape, and continue to ask probing questions to see if the child recognized the landscape as the same form. The constant state of fluctuation renders Piaget's request to describe the subject's state nearly impossible. In the case of *A New Nature* (Dorf, 2021), the viewer is presented with an impermanent moving target that is not only in constant rotation, but also changing form from one moment to the next. Eventually the rotating landscape divides into three identical 3D-rendered mountains split into the additive color channels of red, green, and blue. When separated they are independent entities, but when combined they compose an image that represents the fully realized spectrum of color and light. Functionally, digital images are presented with all their color channels combined together so that the image is more or less a reflection of a sensory experience or an observation; similarly, scientific ideas are presented as cohesive and generalized frameworks that otherwise emerge from many disparate sources of empirical information. When an image is broken apart, as in Figure 1B, the viewer is challenged to consider how even the most basic ideas, observations, and environments can be infinitely split or combined, revealing something foreign and strange in a new and unexpected manner. This is a process that both scientists and artists are constantly enacting.

Conduits for Collaborative Seeing

The question of asking what one sees and how one sees it is a more complicated inquiry than it might seem. In the case of the 3D-rendered mountain splitting apart (Figure 1B), the challenge presented is that if everything is in constant flux, how do we interpret what we are observing? Despite their different approaches, scientists and artists both run up against this problem, whether considering, for example, plants adapting to rapidly changing climate conditions, or the ever-shifting relationship among humans, technology, and nature. Figure 1C and 1D illustrate two different moments of interfacing with the world. Figure 1C shows the hand of an artist reaching into a small pool of water only to be met with a graphic grid that lays atop the water itself; Figure 1D shows a scientist in the field noting the timing of an observation of an interaction between plant and pollinator. What both images help to reveal is that the human observer is the conduit for seeing, observing, and understanding. The scientist and the artist bring with them different histories and toolsets for interfacing with the world, but they both share the common feature of the human acting as the filter for translating the sensory experience of the world—the observation—into knowledge.

The methods of observation of the scientist and artist can be very different, but something that is not so obvious is that the goals of the scientist and artist are often shared. Figure 1E investigates this idea with two series of images that illustrate a narrative arc of the passing of time building up to a discrete event. The top row illustrates a slow zoom sequence of the formation and dissolution of an interaction between a flower and a bumble bee; the bottom row illustrates the sequence of a graphic-loading interface of a unicode flower, which spins in the center as the sequence progresses. From one perspective, they represent two divergent narrative arcs as seen from their deeply contrasting aesthetic representations. But from another perspective, they both center on the passage of time and the temporal sequence of the completion of a natural event (e.g., CaraDonna et al., 2014, 2017, 2021; Post, 2019). What Figure 1E seeks to interrogate with the juxtaposition of these two sequences is the question of seeing, observing, and interpretation. As with the other elements of Figure 1, we continually ask: what are we seeing, who is doing the seeing, what is the mode of observation, and how is it all interpreted? Critically, it is not so much that one way of seeing or knowing is better or more accurate—instead, we argue that together, we have a fuller understanding of the world that reaches beyond that of the quantitative, qualitative, logical, and emotional.

Novel Ways of Knowing Nature

The scientist and the artist can begin with the same source of influence and the same set of information (plants, animals, and their interactions); use different means of analyzing, observing, and understanding (population dynamics, ecological networks; color, light, sound); and naturally resolve on quite different results (e.g., CaraDonna et al., 2017; Dorf, 2021). If the collaboration between the two is simply art in service to science, or science in service to art, then new ways of knowing do not easily emerge. What we have learned over nearly 10 years of bidirectional sharing at the confluence of science and art is that there is much to be gained through trustful and open collaboration. Such collaboration has helped to reveal to us that there is no one result that is greater than the other. Instead, we find that knowing and knowledge production is constantly in flux like the surroundings that seed our inquiries. If we allow it, each approach informs the other, helps to challenge their mutual assumptions, and shifts perspectives.

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The Integration of Botanical Science, Art, and Agency

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The combination of art and the botanical sciences can address global and local issues in ways that resonate with communities. Marginalized societies, plant species, and whole ecosystems are suffering the consequences of a rapidly changing climate (IPCC, 2023). These challenges require multidisciplinary approaches, which extend beyond the field of botanical science. We, the authors, propose that socially engaged art practices rooted in a history of activism combined with a deep western scientific understanding of plant communities can help address the issues of climate change. We are a group of creative researchers from various disciplines, all part of the Backyard Phenology Project (BYP) at the University of Minnesota (UMN). In this article, we describe this project and related endeavors. We hope that these examples can help readers see their place in both local and global ecosystems and build communities through the integration of the arts and botanical sciences.

Backyard Phenology

The BYP is an ongoing art and community science platform that engages people to become more attuned to the seasonal cycles of nature (phenology) and foster dialogue about the influence of climate change on nature (Backyard Phenology, 2023). The project launched in 2016, with support from the Northern Lights arts organization and a UMN Grand Challenges grant. The project was founded by Professor Rebecca Montgomery, a forest ecologist, and Professor Christine Baeumler, a socially engaged artist. Other founding collaborators include Professor Mae Davenport, Beth Mercer-Taylor, and Kate Flick. The BYP team, assisted by various researchers and volunteers, listen to and record stories of people around Minnesota in a mobile recording studio called the Climate Chaser. Participants are invited to share stories of plants, the environment, and our changing climate with the BYP team, and then continue to document their natural observations on a printed phenology calendar. A BYP podcast featuring the recorded stories is available on the BYP website https://phenology.umn.edu. The Climate Chaser is a retrofitted vintage chrome camper that has been brought to numerous events and sites, including

Figure 1. *(A) The Backyard Phenology Project: The Climate Chaser recording studio is parked next to a natural ink workshop tent hosted by Kimberly Boustead at Franconia Sculpture Park. (B) Pedagogy: Students in the Art and Ecology class harvest buckthorn berries. (C) Maria Park and students experiment with shifting the pH of natural inks, thereby changing the colors. (D) Reframing Our Relations: The multi-course meal was prepared by team members from foraged and locally sourced ingredients including staghorn sumac, spruce tips, and crayfish. (E) A Plant People Project: bur oak (*Quercus macrocarpa*) print and haiku next to various tinctures from oak bark. The class learned about the role of oaks in the Stop the Reroute fight (1999), and its role in oak savannas. Check out the Plant People archive-in-progress: z.umn.edu/PlantPeople). (F) Seed Sharing: Seed packet preparation by Chotsani Elaine Dean.*

art festivals, an American Indian reservation, a local farm, and the Minnesota State Fair. In 2022, the camper visited Franconia Sculpture Park where Baeumler invited Minnesota artist Kimberly Boustead to lead a natural ink workshop alongside the Climate Chaser (Figure 1A). BYP encourages scientific observation and welcomes diverse ways of knowing and experiencing the environment through social engagement, collaboration, and empowerment of participants.

Pedagogy

The themes and values of the Backyard Phenology Project are fully present in the courses that members of the BYP team co-teach at UMN. The *Art and Ecology* course, currently taught by Christine Baeumler and Maria Park, an artist and graduate student in ecology, takes an experiential and place-based approach to engaging students in learning about ecology, eco-art, and socially engaged art practices. Following the collaborative BYP event at Franconia, artist Kimberly Boustead joined Baeumler and Park to lead students in harvesting common buckthorn berries (*Rhamnus cathartica*) lining the Mississippi River. The non-native species has been reported in every Minnesota county and negatively impacts the environment in many ways (EDDMapS, 2023). Employees from the Minneapolis Park and Recreation Board supplied tools and taught students about the ecological implications of buckthorn. Boustead then led students through the process of creating ink and painting with the buckthorn berries (Figure 1B, C). In one class period, students learned about the ecology, art, and chemistry of a plant in a completely hands-on experience.

During the semester, students in *Art and Ecology* find a "sit-spot" location that they return to consistently. Based on the practice of taking phenology measurements, students are prompted to observe changes in the environment and reflect on their chosen location as the seasons shift. Setting aside the time to regularly disconnect from the busyness of everyday life and connect with a place in nature has helped students care for their mental health in addition to the environment. The sit-spot practice is also fostered in a UMN Grand Challenges Curriculum course titled *Making Sense of Climate Change: Science, Art, and Agency*, currently taught by Montgomery, Baeumler, and Park.

Reframing Our Relations

As noted above, Franconia Sculpture Park has been a site of artistic and ecological engagement for the BYP team. In 2022, the BYP team, led by BYP member Christian Bell, hosted an event titled, *"Re-framing our Relations: Complicating the invasive species narrative through participatory art and science at Franconia Sculpture Park."* The interdisciplinary team of artists and scientists engaged local stakeholders and community members in the sharing of food, stories, and knowledge about non-native species (Figure 1D). A major goal of the project was to reframe the ways in which introduced species are viewed and managed. A more respectful vocabulary of animacy (Kimmerer, 2017) could be used instead of colonial language that vilifies species by referring to them as "invasive," "novel weapons," and in need of "eradication" (Estévez et al., 2015). Learning from Indigenous practices of land stewardship, and opening minds to the possibilities of long-term ecological restoration practices, can allow for a more sustainable future (GLIFWC Climate Change Team, 2023).

The act of facilitating conversations over a shared meal is a socially engaged art practice that has been implemented by contemporary artists such as Seitu Jones and Marina Zurkow (Gruenewald, 2014; Cadieux et al., 2019). This particular shared meal and conversation was curated to encourage participants to explore their own relationships with plants, particularly non-native species. Conversations spanned topics of ecology, land management, colonialism, reciprocity, and different ways of knowing. Participants exchanged stories and ideated pathways forward together.

Plant People

Plant People is a research initiative documenting oral histories of plant practitioners in Minnesota to uplift the history of healing plant knowledge in the midst of the Western medical tradition. Jessie Merriam, a graduate research assistant for Backyard Phenology and Plant People, was inspired by BYP workshops at Franconia to help Plant People identify the healing relationships artists also have with plants. Merriam and herbalist Emily Ryan developed an ongoing series, "The Ways of Plants," at Fireweed Community Woodshop in Minneapolis to explore the history, sustainable harvest, and culinary and medicinal uses of native plants while teaching students to make their own woodblock print of the plant (Figure 1E).

Seed Sharing

Seed harvesting and sharing is a project that is essential in the studio practice of Chotsani Elaine Dean, a member of BYP and Assistant Professor in the UMN Art Department. While living in South Carolina in 2017, Dean learned where to find the seeds of a flowering plant by spending time with two of her garden plants. When Dean noticed the open and offering seed pod of the pansy (*Viola × wittrockiana*) and nasturtium (*Tropaeolum majus*), her curiosity was sparked. Dean learned how to identify the flowers, followed the phenology of the plants, wrapped flowerheads in cheesecloth to catch seeds, and started to make her own seed packets (Figure 1F). Dean continues to give people her seed packets to continue the practiced tradition of across-the-fence gardening in this modern era.

Conclusions

The intersections of art and the botanical sciences can foster innovative community engagement initiatives that address the pressing challenges of climate change and dominating non-native plant species. People may initially question and misunderstand the role of socially engaged art in the botanical sciences. But by helping people interact and reflect upon plants and natural places they care about, we have seen shifts in attitude and perspective. We have found that approaching projects with an open mindset and willingness to engage with people from different backgrounds lead to exciting collaborations that cross societal boundaries and generate opportunities to co-create a sustainable world.

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"Art of Horticulture" Course Cultivates Creativity

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Since 2003, Cornell University's Art of Horticulture course has engaged students to use plants for creating art (natural dyes, willow weaving, papermaking, etc.) as well as the subject of art (botanical illustration, photography, printmaking, etc.). But founder Marcia Eames-Sheavly's learning objectives went far beyond the basics of plants and paints, challenging the traditional boundaries of university horticulture curricula. This unique course encourages students to develop a distinctive lens to view the world and to take a deep exploration into self, the classroom environment, and their broader community.

The curriculum has continued to evolve and respond to changes in our scientific knowledge and social awareness under the leadership of Emily Detrick, who has taught the course since 2018.

The course vision is as follows:

Ground Students in the Landscape

Detrick has strengthened deep connections between the course and Cornell Botanic Gardens, where she serves as Director of Horticulture. Plants from the Botanic Gardens provide both inspiration and materials for creating art and a seasonally changing palette that grounds students in the cycles of the natural world. The gardens offer a living laboratory where students participate in activities like a mindful botany walk, create plant-based installations that are accessioned into the living collections, and learn about biocultural diversity through interpreted displays (Figure 1).

Cultivate a Diverse and Inclusive Classroom Culture

Although based in Cornell's College of Agriculture and Life Sciences, students come from across disciplines and with varying experiences in horticulture and art—majors as diverse as Engineering, Animal Science, Computer Science, Hotel Administration, and Architecture, in addition to Plant Sciences and Fine Art. The weekly sessions help students connect creativity and botanical sciences through hands-on activities that hone observation and plant biology skills as well as an understanding of the principles of design

Figure 1. *Art of Horticulture students create moss "land art" installation at Cornell Botanic Gardens using native mosses and ferns. If conditions are right, the students' individual moss arrangements will grow and merge into a single, naturalized composition of brocade moss (*Hypnum imponens*), haircap moss (*Polytrichum commune*), and marginal wood fern (*Dryopteris marginalis*).*

in living forms. Students weave their personal experiences and interests with their botanical arts exploration, a process that naturally creates vulnerability. They engage with their peers to ask questions, seek ideas, and support one another when stepping out of their comfort zones. These practices help develop group as well as individual problem-solving strategies and contribute to an inclusive, collaborative classroom culture.

Connect to Art-Science Community

Perhaps as important as the curriculum is the insight students gain into a variety of career paths through interaction with contemporary artist-scientists. In addition to hosting artists in the classroom, students take field trips to a local gourd artist's studio and a fiber artist's dye garden. Additionally, students engage with renowned artists who visit campus, such as Brazilian street artist Eder Muniz, who created a two-story botanical mural at the Botanic Gardens in 2019. Nigerian-American artist and poet Precious Okoyomon led students in a nature-inspired poetry workshop in 2022.

Deepen Knowledge of Campus Programs and People

Students visit Cornell University's Herbert F. Johnson Museum of Art and Cornell Rare and Manuscript Collection to see examples of historic and contemporary plant-inspired art. Cornell artists-scientists lead classes, such as Cornell Soil Health Lab manager Kirsten Kurtz, who teaches the importance of soil health as well as how to paint with it. SIPS Communications Specialist Craig Cramer teaches botanical scanning and digital manipulation. He also documents student work and manages the course website, where images of past student work can be found (https://blogs.cornell.edu/artofhort/).

Develop Observation Reflection and Documentation Skills

Students learn creative ways to document their observations of plant life, such as cyanotypes, pressing and drying techniques, and ink impressions. Required readings and writing assignments hone their reflection skills to connect self, art, and the natural world in a broader context. Students apply their unique interests, perspectives, and expertise to create capstone projects. When presenting, they show evidence of their new botanical understandings by discussing the nomenclature, morphology, life histories, and ethnobotanical uses of plants they have come to know intimately through their projects, as well as their successes and challenges with newly learned artmaking techniques.

Create Lifetime Impacts

Overall, students learn the value of engaging creatively with plants to foster their own and community well-being. One reflected, "I have gained… lessons not only about the intersection of art and science, but about reflecting in myself, taking time to look up at the natural world around me, connecting with my peers, using my voice with intention, and trying things that scare me."

Reaching Across Audiences: Connecting to and Communicating Botanical Concepts Through Art

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With increasing anthropogenic and climate-induced changes to our ecosystems (Groffman, 2014; Kidwell, 2015), it is more imperative than ever to foster a kinship between people and their environment and to enhance communication of ecological knowledge across audiences, from scientists to students and the public. Cultivating a personal connection to plants—from individual species to their foundational role in ecosystems—is especially critical, because doing so promotes a desire for conservation and a deeper understanding of our world's biodiversity. While many media platforms, such as nature documentaries, tend to focus on mammals (Howlett et al., 2023), plants account for 80% of total biomass on Earth (Bar-On et al., 2018) and serve as the building blocks of food webs. Yet nearly 40% of all plant species are classified as rare (Enquist et al., 2019).

Artwork presents one key avenue for promoting botanical literacy by creating an emotional, cross-scale connection to plants and fostering a bigger-picture context of plant responses to climate change. While detailed and highly accurate botanical illustrations date back centuries and were crucial in early efforts to record plant species prior to photography, recent trends in ecological education in STEAM (science, technology, engineering, art, and math) have moved toward a more holistic view of plants embedded within their abiotic and biotic environments. Parallel trends are occurring in the world of fine art, with pieces focusing on fostering a personal connection between humans and the botanical world. Here we examine how art promotes this connection between people and plants across biological scales.

Individual and Species-Level Scale

One of the most direct paths humans may take to connecting with plants is by bringing houseplants into their homes. Greening a home through the introduction of houseplants benefits mood and task attentivity, with even individual plants inspiring creativity (Shibata and Suzuki, 2002) and motivating artistic compositions that further botanical understanding. Houseplants skyrocketed in popularity during the COVID-19 pandemic (Phillips and Schultz, 2021), quickly becoming muses for creative projects such as leaf preservations, still life paintings, and artfully arranged terrariums. Plants also inspired artistic competitions, such as one hosted by the Denver Botanic Gardens inviting artists to submit pieces representing how houseplants, gardens, and nature supported them through the COVID-19 pandemic (Denver Botanic Gardens, 2021) (Figure 1). During this time, an increase in emotional, sentimental attachment to plants also became evident. In addition to inspiring creativity, houseplants also benefit mental health as well as encourage mindfulness and self-care (Bringslimark et al., 2009). It is perhaps for this reason that many people who were quarantined away from both social and ecological interactions came to see their houseplants as sources of personal joy, inspiration, and comfort during this time. Through art, this quiet connection may be succinctly and poignantly shared with any who may relate or sympathize with a similar connection to their personal plants.

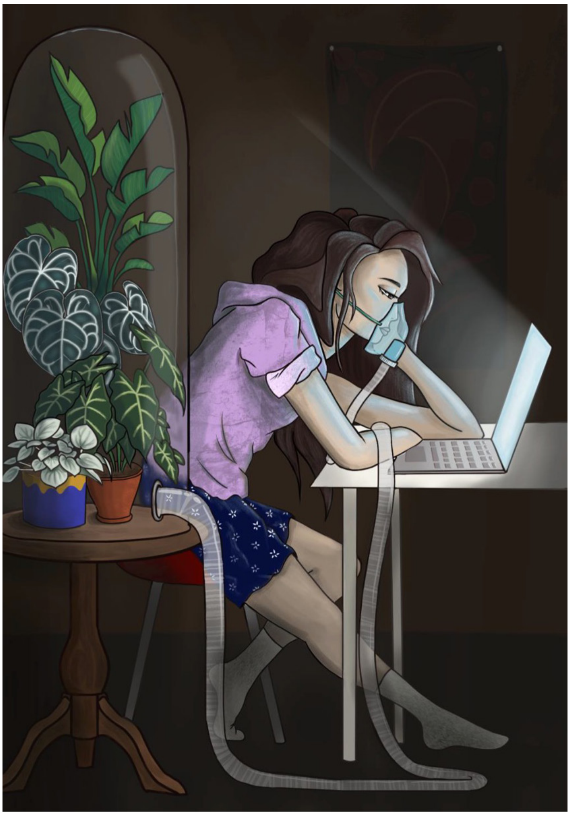

Figure 1. Life Support, *2021. Digital art by Janette Davidson. Image symbolically depicts a connection between people and plants, in how houseplants supported their caretakers through the quarantine period of the COVID-19 pandemic. This piece was created for the 2021 online art competition hosted by the Denver Botanic Gardens, "Plants Through Pandemic."*

Interactions with plants at an individual and personal scale also improved many owners' knowledge of botany. Plant ownership exposes non-academics to botanical concepts such as environmental requirements, anatomical terminology, key features for identification, and conservation concerns such as poaching of rare plants. From this increased knowledge arose artistic infographics and care sheets, spreading information on these concepts in a visually accessible medium (Briscoe, 2020).

Community and Ecosystem-Level Scale

The positive associations art can engender with indoor plants may be extended to connect people with larger natural systems, and botanical illustration continues to play a valuable role in the study of ecosystems. Artists may also look beyond the individual to capture the lives of plants within their larger landscape context.

Landscape fine artists often create artwork of plant communities at this moderate scale, moving beyond detailed renderings into the sphere of artistic interpretation of plants within their ecosystems. Using observation and knowledge of plant communities, artists convey the sense of a landscape using loose brushwork and rich color. The popular plein air movement (a French phrase meaning "in open air"), where artists are simultaneously inspired by and create directly in nature, began in the early 1800s, and was popularized during the Impressionism Movement (Callen, 2015) and continues to this day. This technique captures the effects of sunlight and shadow on a landscape, allowing artists to convey their emotional connection and impressions of

Figure 2. Perfect Day Ahead, *2023. Oil on panel by Jennifer Shoemaker. Landscape of sage and lodgepole pine ecosystem, with a harmonious hiking trail snaking through. This piece was created as an example of integrating historical and modern plein air techniques.*

the landscape directly to viewers (The Art Story Foundation, 2023) (Figure 2). Through landscape art, viewers are invited to become absorbed in the feel of a plant community, developing a sense of place and appreciation at an ecosystem level (Malafronte, 2009). In this medium, we see ourselves not only observing the world of plants within their landscapes, but becoming immersed and ultimately belonging to that same world. As such, these landscape paintings can foster a personal desire to conserve ecological communities (Ostendorf, 2017; Renowden et al., 2022).

Global Scale

Art also has the potential to deepen general understanding of abstract botanical concepts, such as the risks of climate change to both humans and plants. In the modern milieu, where 40% of plant species face extinction due to threats such as climate change (Antonelli et al., 2020), promoting education of how plants are being affected on a global scale is imperative in eliciting support for conservation of these species. Through art, seemingly abstract data such as changes in temperature and climate patterns through time (Figure 3) can come alive and inspire action. However, communicating such topics, especially to school-aged audiences, presents a challenge because the concept may seem remote. An interactive art medium is therefore well suited to reach this audience and inspire students to take action.

Figure 3. *Collection of Tempestry (Barber and Gilson, 2023) educational and community artwork projects led by Dr. Alexandra Rose, depicting changes in temperatures over time in two North American cities: Mazatlán, Mexico and Boulder, CO, USA (A, B), and illustrating the global temperature during the birth year of project participants at local community events (C, D).*

For young students, art can serve as a colorful and captivating communicator of science—particularly if the student is involved in the creative process. Studies show that incorporating art into learning environments may help students better retain information (Gullatt, 2008), and thus is a valuable tool in lessons about climate change. Through the creative process, students can directly connect to the data of their local environment (Figure 3A, B), promoting understanding for how this global problem can affect their smaller scale, local botanical communities. A similar artistic approach may be taken with communicating global science to a multi-generational audience. Involving citizens of varying ages can be powerful for demonstrating trends through time at different points in their lives, for example by asking participants to attach color-coded cloth strips representing the average temperature in a given location during their birth year to a timeline (Figure 3C, D). Having the public contribute to interactive art exhibits at local community events, such as at libraries or farmers' markets, can convey a concise visual message on climate change impacts. Thereby, it can serve to initiate conversations about climate change or encourage families to contribute to conservation efforts themselves by fostering an emotional connection between plants, their ecosystems, and changes in climate.

Promoting Scientific Literacy through Emotional Engagement

Art's distinctive ability to establish emotional connections between viewers and the botanical world across scales, spanning from individual plants to botanical communities and a global context, make it an effective tool for communicating complex ecological concepts, eliciting pro-environmental attitudes and behaviors in society (Kals et al., 1999) and garner support for solutions-focused conservation research. In an era of global change, public understanding, socio-political interest, and economic support for plant conservation are more critical than ever (Balding and Williams, 2016). However, people often struggle to connect emotionally with plants, and many of the concepts behind cutting-edge conservation research can be difficult to convey to non-specialists due to their abstract, multifaceted nature. Education about conservation topics can greatly enhance community engagement with conservation work (Ardoin et al., 2020) and scientists are increasingly reaping the benefits of artistic approaches to communicating complex topics (Curtis et al., 2012). Furthermore, art-science integration can increase access to scientific knowledge that can be restricted behind paywalls.

For example, plant functional traits are grounded in theoretical concepts that can be used to generate general predictions for how species may respond to their environment and global change. However, few people are well-acquainted with traits, and the definition can be difficult to comprehend, especially for mathematically derived botanical traits such as specific leaf area (Violle et al., 2007). In cases such as this, artwork can facilitate understanding and engagement with botanical concepts and conservation principles, such as how traits are used by research scientists to predict plant survival and adaptation in response to global change (Figure 4). The brevity and illustrative nature of the graphics served to share examples of conservation work and increase social capital for trait research by generating empathy for the pressures that plants face. This approach is merely one way art can distill abstract concepts into engaging visual stories that stimulate empathy and support for conservation. Other artists have leveraged similar approaches, such as comic strips (Kozik, 2021), to disseminate conservation science in a problem-solution framework. Artistic displays have immense potential to make science more approachable and to arouse curiosity and empathy for the botanical world.

Conclusions

Although art may appear, at first glance, to play a fading role in the academic world of botany, it is in fact one of our strongest tools for communicating science. Most people have an innate connection to nature, and whether it is strongest on a smaller personal scale with individual plants or a larger scale with landscapes, this connection can be utilized to increase awareness about plants and the challenges they face on a global scale. Botanical art can also serve as a gateway to awareness and aesthetic appreciation of the plant environment and its associated organisms, from microbes to pollinators. Art is a unique and valuable tool we must use to tap into humanity's connection with plants, to not only improve the efficiency and clarity with which we communicate science, but also stoke a passion for botany and conservation outside of the academic world.

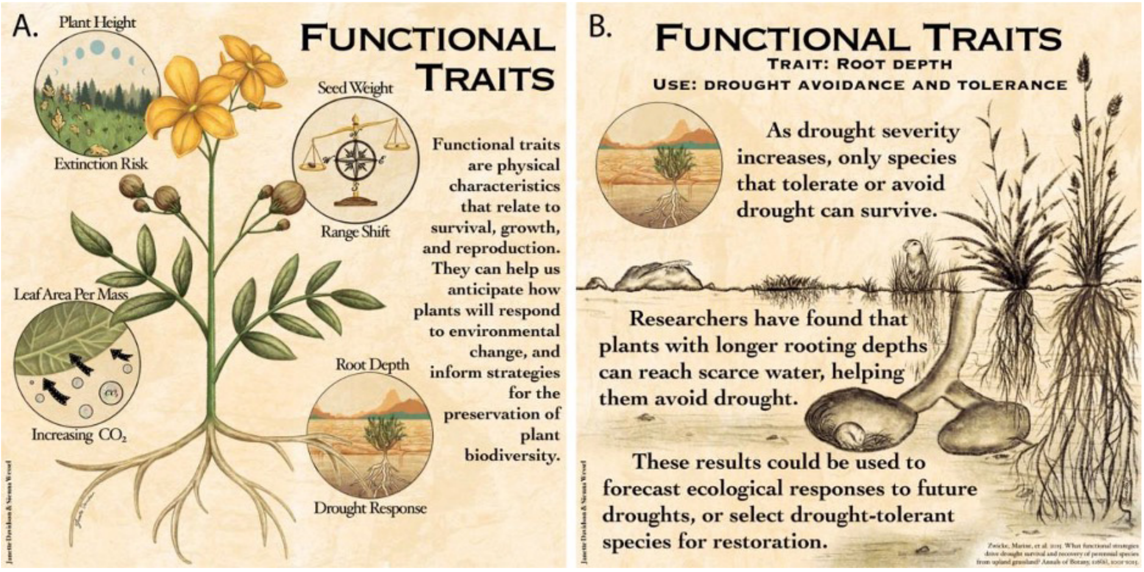

Figure 4. Functional Traits, *2022. Digital art by Janette Davidson, authored by Sienna Wessel and Janette Davidson. This shows two excerpts (A, B) from a five-part series of informational artistic graphics defining plant functional traits and describing how they can be used to inform conservation efforts. The series was shared to a broad audience via university-affiliated social media and a public gallery showing.*

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Reconnecting Science with the Visual Arts: Teaching the Art of Biology

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"What is our mission? What do we have to do? I think our mission is to reconcile, to reintegrate science and the arts, because right now there's a schism that exists in popular culture. . ."
Mae Jemison, TED Talk (Jemison, 2002)

The schism between art and science is relatively recent. Although scientific illustration has been around for centuries, and many artists have sought and seek inspiration from nature, after the mid-19th century the disciplines dichotomized, as scientists claimed their own space and the rise of technology changed the world. In 1959, British chemist, politician, and novelist C. P. Snow, in a lecture titled "The Two Cultures and the Scientific Revolution" (Snow, 1961), observed that the gulf between literary intellectuals and scientists was a deterrent to human progress, since those in the humanities had no way to communicate with those in the sciences, and vice-versa.

Mae Jemison—first African-American female NASA astronaut in space, MD, professor, entrepreneur, and dancer—makes a powerful point in her TED talk about this disconnect and argues that it is necessary to reunite the two to facilitate understanding and avoid societal problems (Jemison, 2002). In the College for Women at St. Catherine University, my art colleague, Carol Chase, and I developed a course that braided our disciplines. *The Art of Biology* offers both a botany laboratory and an art studio, satisfying core requirements in both areas (Figure 1).

We address historical connections between art and botany, the eventual separation of the disciplines, and current efforts to bring them together to support overall student learning. For the past 15–20 years, K-12 schools, colleges, and universities have worked to meld these disciplines, resulting in courses where art and science are used to complement learning in both. The K-12 realm has seen the rise of STEAM as a discipline, where art is used to facilitate student learning in science (STEM) courses (Snow, 1961; Hanriksen, 2014; Quigley et al., 2017) and in afterschool activities (Tott et al., 2020). Interdisciplinary courses in medical schools, nursing programs, and in

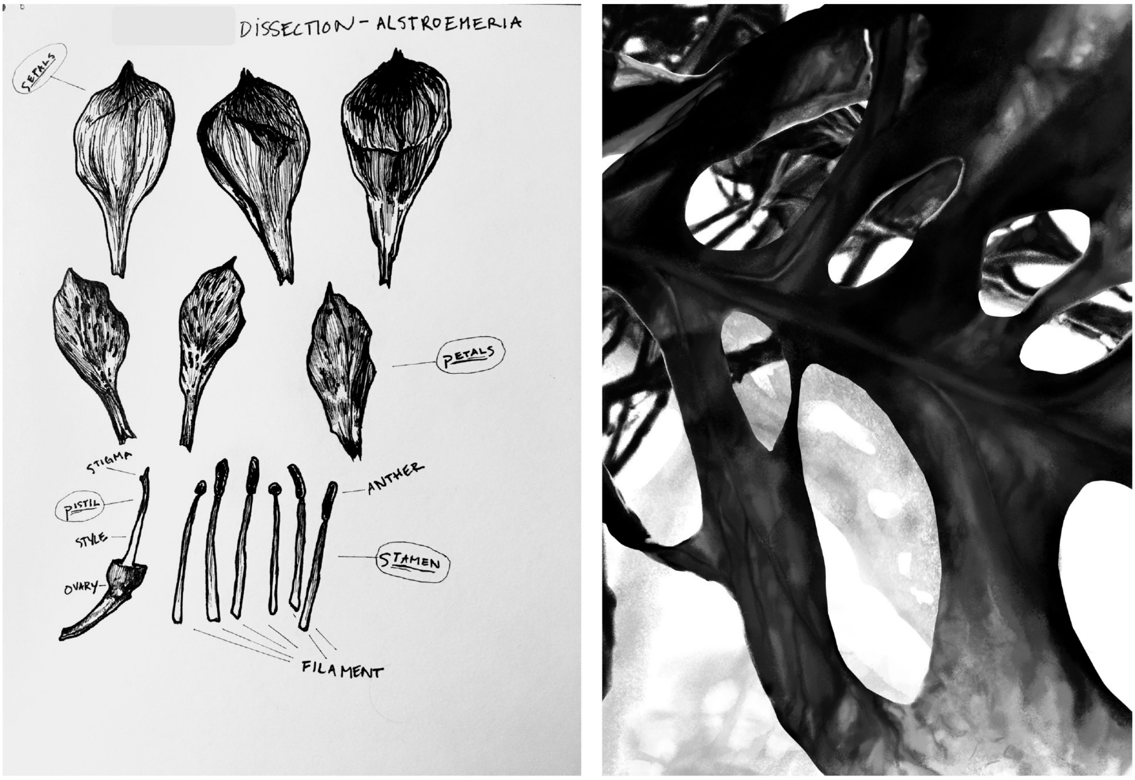

Figure 1. *St. Catherine University Art major Blue Edwards created these two images for the Art of Biology class. The image on the left is a lab sketch (pen and ink) of one of the flowers dissected in lab that day. On the right is Blue's digital drawing for the final creative art project—depicting a look through the holes in a* Monstera *leaf. Permission granted to use images and student's name and major.*

biological sciences (Baldwin and Crawford, 2012; Flannery, 2012; Frei et al., 2010) help students hone observational skills by creating works of art that help them better understand connections among, for example, the plant structure/function concepts they are learning about, the details of those structures they must "see" to draw, and how those structures relate to functions. Exploring the use of art as a learning mode in science is highly regarded in some areas of biology, where faculty have long recognized that developing drawing skills to depict what one sees under the microscope, in a dissecting pan, and in nature, allows students to deepen their ability to see similarities and differences in what they are studying (Klugman et al., 2011).

Our course also brings to the fore the concept that both artists and scientists are creatively engaged in their disciplines and use similar modes and practices. As noted by Beveridge in *Seeds of Discovery* (1980): "The basic process of innovative thinking is the same in science, the arts, business, or any occupation that is not purely routine or just following instructions."

We meet for 5 hours each week: one 2.5-hour class is in a biology lab and the other 2.5-hour class is in an art studio. Lab time is spent learning the structure and function of members of the plant kingdom through lecture, lab, and field observation. In the studio, students learn to address a blank page creatively, and how to use various media, such as graphite, pen and ink, and watercolor. We make explicit the connection between the biological observation students do in the lab and the drawing practice they complete in the studio. The text we use, *Botany for the Artist: An Inspirational Guide to Drawing Plants by Simblett* (2010), complements what students are learning in the lab and studio. Simblett reinforces the connection between history, art, and biology as she combines botanically correct and beautiful drawings and paintings with descriptions of plant organs, habitats, and instruction on how to produce clear botanical illustrations that are also works of art.

To enhance student learning, we invite local artists, such as Marilyn Garber, Founder of the MN School for Botanical Art, to teach classes, and visit museum special holdings, such as the Maria Sibylla Merian print collection at the Minneapolis Institute of Art. Walks in nature, from our campus full of flowering plants to the Eloise Butler Wildflower Garden in Minneapolis, help students understand the wide variety of plant structures and how they evolved to facilitate a plant's ability to thrive, and gives them a chance to enjoy the natural world.

In addition to a weekly sketchbook and quizzes that test student knowledge of plant structure and function and art concepts and practices, students produce two exhibit-ready projects: one at mid-term and one at the end of the semester, where they combine what they have learned to create pieces of art. These are presented at "openings" complete with an artist's reception, which is great fun. The course is enjoyable to teach, and students bloom (pardon the pun) throughout the semester as they become more proficient in both art and science.

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From the *PSB* Special Issue on Art in the Botanical Sciences

Nature Journaling: Sharing Perspectives Between Art and Science

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It is the height of summer and you've ventured out on your favorite trail. Late afternoon sun sets the overhead leaves aglow, and the scent from yesterday's rain emanates from the soil beneath your feet. A bird, plumed with vibrant stripes of yellow and black, perches amid the pine boughs and calls a looping, muddled chirp. You pause in wonder, taking in this new sight and sound among the otherwise familiar landscape. Taking a notebook and pencil from your pack, you roughly sketch the bird's shape and a map of the woods around you, jotting a few words to describe its distinctive call. Another bird calls back, and you note the number of birds joining the chorus. This bridging of scientific observation and artistic practice is nature journaling.

Nature journaling invites us to connect with our curiosity for the natural world by keeping records of our observations (Figure 1). Documentation can include words, numbers, sketches, diagrams, photos, collage, maps, and found objects. Anyone—even those not trained in art or science—can use nature journaling to cultivate mindfulness and wonder, build critical thinking skills, develop greater perception, and deepen their understanding of the environment. Nature journaling instruction can be adapted to any audience, from children curious about basic processes in nature, to biology students supplementing their academic training with real-world observation, to those seeking to spend quiet, intentional time in nature.

To share the practice of nature journaling, we invite scientists, artists, and the public to engage in an annual Nature Journaling webinar series. The program was developed in 2020 as a partnership between W. K. Kellogg Biological Station (KBS) and the Kalamazoo Institute of Arts (KIA) with the goals of building participants' understanding of ecology and evolution, developing nature drawing skills, and encouraging journaling practices. During each of four webinars, a KBS scientist teaches an introductory ecology seminar focused on a particular biological scale—landscapes, communities, populations, or organisms—and presents an example from their research. For example, a lesson on landscape ecology includes a case study on local habitat restoration (e.g., prescribed burning to maintain a native grassland) whose goal is to connect patches of habitat for native insect pollinators. A KIA artist then follows with a brief lecture on art concepts that correlate to the week's themes and, using a photograph

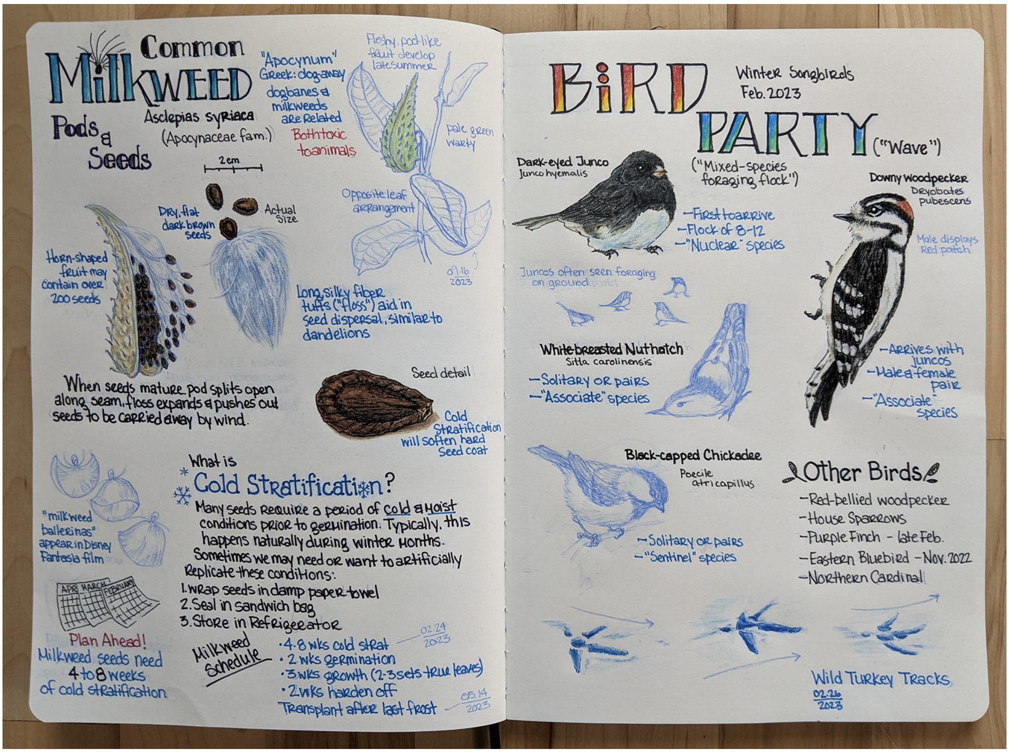

Figure 1. *Sample nature journaling page provided by 2023 participant Briar Hallowstone.*

from the scientist's research, guides participants through an observational sketch of a landscape, species interaction, or individual organism, each week demonstrating a new technique. Participants reflect on the activity and talk through challenges they encountered.

Since 2020, we have partnered with ten scientists and two artists who have presented a range of ecology concepts and creative techniques in an accessible format. Ecology presentations have included topics such as prairie ecology and management, the role of soil microbes in bioenergy cropping systems, and moth species identification. Art segments have incorporated art history, math, and visual sciences to align instruction with each week's science theme. For example, following a presentation on the mutualism between ants and extrafloral nectaries, an artist demonstrated that accurate proportions can be drawn by interfacing multiple visualization techniques. First, students were taught to reproduce correct shapes from observation using their reference image to measure lengths and a mutual angle at two scales. Then, by learning to visualize negative space, students effectively used geometric proofs to test their proportions. The blending of these two techniques demonstrated that in art, as in science, the more data that can be synthesized, the more accurate the results. Under the umbrella of "mutualism," this lesson pairing facilitated deeper observation and understanding of the relationship between things that rely on each other, whether they are plants and insects, or lengths and angles.

Our four annual programs have reached 248 participants from eight states. The majority of surveyed participants report improved understanding of scientific concepts (81%) and increased interest in starting or continuing their nature journaling (95%). Participants deepen their relationship with nature and art, are compelled to be observant, and gain new knowledge about local ecology in their own backyards.

Plants as a Case for Creative Collaboration: Designing the Interactive Art-Science Exhibition *Meaningful Beauty*

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KEYWORDS

animation, augmented reality, Caprifoliaceae, interactive media, fusion, graphic design, honeysuckle, *Lonicera,* science communication, undergraduate education

Scan this code with your phone camera to reveal augmented content throughout the article.

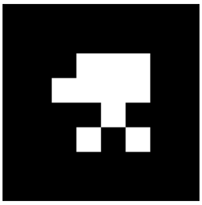
Keeping your phone's browser open, scan this and the other black and white symbols throughout the story.

Exploring Plant Diversity Through Exhibit Design

From the perspective of a botanist, one might describe honeysuckles (*Lonicera*, Caprifoliaceae) as a group of nearly 140 species largely distributed in the northern hemisphere, boasting an array of diverse leaf, flower, and fruit forms. To the general public in North America, however, awareness of honeysuckle is usually limited to the sweet smells of *Lonicera japonica* on summer walks through the woods, or perhaps the tenacious creep of *L. morrowii* into their yards and gardens. Inspired by the ongoing research of a multi-institutional team studying honeysuckle evolution—substantially informed by the work of a graduate student at Yale University and led by faculty at The College of New Jersey (TCNJ)—a team of nearly 50 undergraduate students collaborated to develop an art-science exhibition that invited participants to view plants through a variety of lenses. This collaborative opportunity provided science communication training opportunities for undergraduate students in science, interactive media, art, and design. Our students used their strengths to broaden awareness of plant diversity and share novel research outcomes on evolutionary studies of honeysuckles through the design and display of the exhibition. Ultimately named *Meaningful*

Beauty: The Vibrant Vocabulary of Honeysuckles, the exhibition featured a rich blend of artistic and scientific imagery, while employing digital and interactive technology to augment information and personalize the experience for each visitor. The exhibition was first on display at the TCNJ Art Gallery in Spring 2022, followed by the Arnold Arboretum of Harvard University during the summer.

Project Development



The exhibition's content, design, and overall visitor experience grew out of a months-long collaboration between student and faculty scientists, artists, designers, and creative technologists at TCNJ. Over the course of the project, scientists and non-scientists embraced the opportunity to share with each other the knowledge, objectives, processes, and tools of their respective disciplines. The primary conduit for this collaborative work was a course in *Interactive Exhibit Design*, offered by the college's Department of Interactive Multimedia, and taught by Associate Professor Christopher Ault, as well as a summer undergraduate research experience.

Interactive Exhibit Design assembled a diverse group of student illustrators, animators, programmers, graphic designers, writers, and more. First offered remotely in the Spring of 2021 due to the pandemic, 16 students collaborated to conceptualize various approaches to increasing the public's appreciation of honeysuckle diversity, while also communicating specific insights from the science team's ongoing research on honeysuckle evolution. Students received institutional guidance from former TCNJ students and the gallery directors from both TCNJ and the Arnold Arboretum. The course was offered again the following semester. Now in person, the course's 17 students had access to the college's "makerspace" to finalize designs and fabricate the components of the exhibition. A key improvement over the previous class was to recruit two biology students as "learning assistants." As the interactive multimedia students developed artwork, text, interactive interfaces, and code, they could dependably turn to the learning assistants to clear up any uncertainty about the science. Some examples of this cross-disciplinary peer teaching included deciphering and creating floral diagrams, assisting navigation of resources such as GBIF and iNaturalist, and commenting on the visual interpretation of fusion in honeysuckle leaves, flowers, and fruits. One of the learning assistants—Biology student Robert King—described the collaboration:

> *"Communicating with a group of students who had little to no biology background was a challenge, but it allowed me to increase my science communication skills along with my own understanding of honeysuckles. One example was explaining to the artists the orientation of flower morphology. Although I was a scientist on the project—not an artist—I am a visual learner, so I sketched all the flower morphologies as part of the process. It helped the artists understand the key concepts and keep the botanical accuracy intact. It also helped me appreciate the more than 140 species of honeysuckles."*

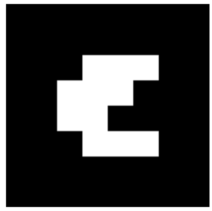
Between the two offerings of the course, the exhibition made significant strides through a summer research program at TCNJ that included two interactive multimedia students and four biology students. Anchored by weekly readings and discussions of Beronda Montgomery's *Lessons from Plants*, both groups together considered some of the factors behind plant visibility—or rather, invisibility—on the part of the general public. The science students on the team were challenged to communicate their knowledge, methods, vocabulary, and tools to the non-science students, one of whom had a primary interest in animation, and the other in user experience design. Armed with these insights, the non-scientists conceived of possible ways to communicate those ideas through art, design, and technology. As the science students came to understand both the goals of the exhibition as well as the tools and processes of their peers in interactive multimedia, they began to share their own ideas for what approaches might be effective for a gallery exhibition. This intensive summer effort established the framework for the entire exhibition and set goals for the exhibit design course in the fall.

Interactive multimedia student Haley Wright held the dual roles of project manager and major contributing artist, while participating in both the summer research program and the fall course. Of the collaboration with science students, Wright says:

> *"We gained a better understanding of the bio team's research by visiting their labs to observe their work, examining honeysuckles growing on campus, learning how to decipher and create various diagrams, studying images of live and pressed honeysuckle species online, and discussing what we can learn from honeysuckles and plants in general. We pushed each other to think differently about our work and how it can be communicated to those outside of our field. As designers, I believe this project helped prepare us for working with a wide variety of clients in the future, as it challenged us to infuse creativity into a subject in which we were not an expert ourselves and developed our ability to design iteratively with the feedback of a client."*

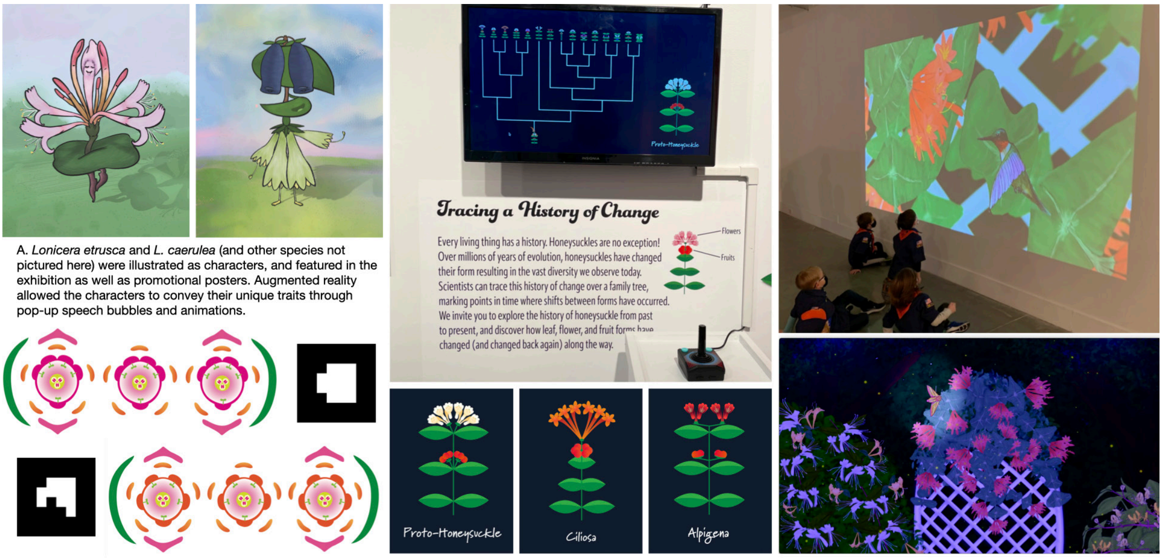
Through the two semesters and summer, the student collective generated a style guide—including a color scheme, font, and tone—which guided all decisions for development of all pieces included in the gallery. Ultimately, the exhibit was organized around six walls exploring themes including regional diversity, morphological diversity, and fusion through a combination of illustration, animation, and graphic design made interactive through augmented reality. Here we describe how various forms of art were combined with scientific content to sustain engagement of visitors in an exhibition meant to communicate the diversity of forms and function of plants.

Animations



Animation is a prominent area of interest in the Interactive Multimedia major, and several students in the *Interactive Exhibit Design* course embraced the opportunity to apply their skills to a project that would be seen in person and at a large scale, as opposed to a more typical platform like a YouTube channel. Both animations were projected to fill entire walls, using short-throw projectors to allow visitors to view this "animated wallpaper" up close without casting shadows (Figure 1D). After considering various areas of the science that might lend themselves to striking visuals, the students arrived at two stylistically distinct approaches that effectively blended science with an aesthetic experience appropriate for the walls of an art gallery.

One animation was inspired by herbarium specimens, displaying black silhouettes of fused honeysuckle leaves against bright colored backgrounds. Elements of the silhouettes moved and morphed, reminiscent of early abstract animation where shapes were painted directly on film stock. The other animation put into motion original botanical illustrations from one of the digital artists in the class, featuring honeysuckles swaying in the breeze, with hummingbirds and bees floating from flower to flower. Close collaboration between the botanists, illustrators, and animators led to a discussion on the nocturnal nature of hawkmoth activity and how to portray this in the wallpaper. As a result, when the scene shifts from day to night, the hummingbirds give way to hawkmoths, and fireflies blink like a midsummer evening. At full size, the animation was so striking that a group of visiting children put their noses right up to the wall and wondered aloud whether it was a movie or a painting.



A. *Lonicera etrusca* and *L. caerulea* (and other species not pictured here) were illustrated as characters, and featured in the exhibition as well as promotional posters. Augmented reality allowed the characters to convey their unique traits through pop-up speech bubbles and animations.

B. Floral diagrams paired with augmented reality provided an opportunity for visitors to simultaneously experience an artistic and scientific visualizations of plant. (Top) *L. hispidula* and (Bottom) *L. sempervirens*.

C. Using a joystick to navigate the tree, users could trace evolutionary pathways and trait transitions to get to a honeysuckle that caught their eye. Verbal descriptions and images of ancestral plant forms assisted users' explorations.

D. Animations of pollinators interacting with honeysuckles were projected large on the gallery walls, setting a vibrant tone for the exhibition. The daytime scene features a hummingbird; the nighttime scene a hawkmoth.

Figure 1. *Selected works from the* Meaningful Beauty *exhibition at The College of New Jersey*.

Augmented Reality

Augmented reality, commonly shortened to AR, is a technique by which digital, virtual content is layered on top of a real-world, physical environment. AR is most commonly experienced through phone screens—when a user scans a special symbol with their phone's camera, the phone continues to display the "real" elements of the scene visible to the camera, while integrating digital content on top of it. This content might range from 3D objects that appear to be actually present in the space, to 2D text boxes offering "pop up" information about one's surroundings. Early in the conceptual phase of the project, the team recognized AR as a sort of magic lens—a handheld translator—that would allow visitors to move back and forth between the art and science aspects of the exhibition. For example, when a visitor scans a floral diagram of a particular species, a 3D model of that plant extends out from the wall in augmented reality (Figure 1B). When a visitor scans a symbol on a playfully illustrated tourist-style map of the United States, they're presented with a digital pop-up of essential facts about honeysuckles common in that region of the country. At the Arnold Arboretum, the team took advantage of an opportunity not available at TCNJ, placing AR symbols with corresponding species of honeysuckle on the arboretum grounds, allowing visitors to scan the symbols and learn more about these plants.

Augmented reality was also key to one element of the exhibition that aimed to establish a connective throughline as well as provide users with hands-on appreciation for the range of morphological diversity in honeysuckles. Through a system the team dubbed *Build Your Own Honeysuckle*, visitors could scan AR symbols at key locations throughout the exhibition and choose from a set of options to create their own personalized, virtual honeysuckle plants on their phones. Tied to the theme of a particular wall—diversity, fusion, plant communication, etc.—one AR location would prompt visitors to choose the arrangement of flowers on their plant, while another location presented a choice of fused or unfused leaves. Once all choices were made, visitors scanned a final symbol to see their unique virtual plant bloom out of a real-world pot in a real-world garden cart, surrounded by fanciful, abstract cut-outs of honeysuckle-like shapes in other pots on the cart. Designing the *Build Your Own Honeysuckle* system demanded a balance of accurate science communication with engaging user experience. The interactive multimedia students worked back and forth with the biology team to identify the key elements that vary between species and endeavored to portray these elements as accurately as possible in a vibrant graphic style consistent with the exhibition's overall look and feel. After several rounds of iterative design among the scientists and graphic designers, the system included a total of 144 different flower graphics.

Interactive Evolutionary Tree

Many students in the Interactive Multimedia major are first and foremost interested in video game design. And while they might not have enrolled in the *Interactive Exhibit Design* course expecting to apply those skills, the fact is museums and galleries are meeting the demand and expectations of their visitors by providing more interactive content, often employing tools from game design. In working to match students' interests with possible topics to explore, a phylogeny appeared to lend itself to game design and would help communicate novel outcomes from the research of the graduate student, Mansa Srivastav. The interactive evolutionary tree was the product of close collaboration among undergraduate scientists who studied these floral traits from living plants, herbarium specimens, and the literature; undergraduate graphic designers who created a cartoon form of honeysuckles that exaggerated the features that differentiated each species without the loss of accuracy; and undergraduate game designers who united these pieces with code and a simple joystick inviting users as young as 4 years old to interact with the outcome (Figure 1C). In observing visitors, we found many sought to find the path that led to a honeysuckle with a certain set of features—perhaps pink flowers and red fruits, or white flowers with small leaves, or orange flowers and fused leaves. This suggests users perhaps saw these plants as part of a pathway—that is a tree marked by a series of changes along an evolutionary trajectory culminating at one of 16 species. Our sense is that further development of this particular design element could yield additional innovations to provide users with a much better grasp of phylogenetic trees and their significance in interpreting evolutionary change.

Outcomes of the Exhibition

After two semesters of the *Interactive Exhibit Design* course, the summer research program, and one final flurry of work by the faculty, student project manager Haley Wright and Gallery Director Margaret Pazella-Granlund, the exhibition opened at the TCNJ Art Gallery in February 2022. The exhibit was then reconfigured to fit the multipurpose space in the Hunnewell Visitor Center of the Arnold Arboretum the following summer, under the guidance of Sheryl White, Arnold's Coordinator of Visitor Engagement and Exhibitions.

Feedback from visitors clearly and consistently suggested that the exhibition was effective in terms of communicating the science, including fostering understanding of honeysuckle diversity and evolution, and that the artistic and interactive elements of the exhibition served to increase their understanding. Throughout the development process, the team often discussed where the exhibition fell on a spectrum from a natural history experience to art experience, and visitors expressed appreciation for our hybrid approach. A tweet from one visitor offered:

Is it art?√
Is it science?√
Is it more than the sum of
art and science? √√√

As the students from both disciplines move on to graduate school and/or positions in industry, they do so having learned insights into the challenge of conveying complex information in ways that are appealing and engaging. Furthermore, they can draw from an experience that demonstrated first-hand the value of shared knowledge, diverse perspectives, and earnest support between collaborators. To our audience, the combination of art and science gave permission to see and interact with plants from a multitude of perspectives that we hope increases their awareness and appreciation of plant diversity worldwide.

ACKNOWLEDGMENTS

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Understanding Plants Through Imagery: Functional Traits, Cuteness, and Narrative

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KEYWORDS

anthropomorphism, belowground storage organ, cuteness, functional traits, narrative, pretense

Although plants are all around us, they are complex, with many features difficult for humans to perceive and understand. Thus, plant bodies and ecology are challenging to explain quickly and easily. Most focus on plants is aboveground, but many perennial herbaceous plants need belowground storage organs to recover from seasonal dormancy or recurrent disturbance. These organs are poorly understood by the public and often ignored or under-represented by scientists (Klimešová et al., 2020), perhaps because they are hidden in soil. Belowground storage organs store resources and coordinate the growth and connection of aboveground stems and leaves with belowground roots; in many ways they are the core body of these plants. To really see and understand the lives of plants, we must consider the whole body of the plant and interpret the role of their traits in plant growth and stress response (Klimešová et al., 2020; Bartušková et al., 2022).

To explain plant life more clearly, we can give plant belowground organs features and signs more readily understood by humans. I will introduce visual signs of the plant belowground and discuss how anthropomorphized cuteness and narrative can bring additional levels of meaning and enjoyment. These tools can be used by anyone trying to introduce or explain these topics to colleagues or the general public, particularly in more informal settings such as presentations, posters, and blogs.

The Visible Plant

Belowground storage organs have great variety in their size and traits, can be derived from roots, stems, or leaves (all three main organ types), and are frequently capable of clonal/vegetative reproduction (Klimešová et al., 2017). Like humans, plant bodies grow, move, and heal, but they generally do this using belowground stems that grow in units to branch and form different structures that are lost and renewed annually or over many years (Klimešová et al., 2017). Belowground organs and their growth patterns can be recognized by many different visible characteristics (i.e., morphological functional traits), although they are often obscured by soil, roots, or their own complex structure (Bartušková et al., 2022).

Plants generally move via growth, and the structure of belowground plant bodies essentially depicts behaviour and maintains the visual signs of life history and response to the environment (Arber, 1950). Visible scars from previous stems can mark age, and the shape of the body can show how it has grown and moved in response to other plants or obstacles (Raunkiær, 1934; Bartušková et al., 2022). Plants can have round carbohydrate-rich bodies for prolonged dormancy, long spreading bodies that fragment and survive after damage, or compact and tough bodies to survive drought or cold (Klimešová et al., 2011, 2017; Bartušková et al., 2022). To understand the complex lives of plants, it is important to represent and even draw attention to the belowground organs because of their importance in plant life as well as their hidden nature underground (Figure 1).

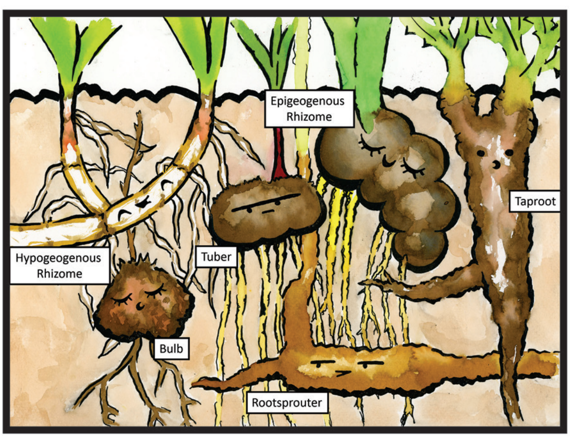


Figure 1. *Diversity of belowground storage organs. Rhizomes and tubers are stem derived. Bulbs are short stems with leaves for storage. Taproots are stem-tissue with a large root below. Rootsprouters are roots adapted to form new stems.*

The Cute Plant

We can add cute features to images to make plants and their lives more relatable and better understood (Lubbe, 2022). Cuteness is visual appeal in an endearing way and portrayed using simplified imagery with the addition of signifiers (see von Ehrenfels and Smith [1988] and Ashwin [1984] for more on simplification and signifiers), typically human qualities that can be used to exploit human attitude toward anthropomorphism (Lorimer, 2007). Anthropomorphism is the use of human qualities inferred onto non-human subjects (Epley et al., 2008), including body shape, limbs, activities, and recognizable facial expressions and emotions (Duffy, 2014). Anthropomorphic interaction is an extension of relationship and empathy to a non-human subject, often used to cope and relate in the real world (Airenti, 2018). This can be held by people as a way of relating to outside subjects (Severson and Woodard, 2018) and can bring comfort and understanding (Epley et al., 2008; Airenti, 2018).

Cuteness is most often applied to material that is for children or entertainment and may be best used in more informal settings, but when carefully applied (Geerdts et al., 2016), these signifiers can convey useful information that could help any audience understand a topic (Chan, 2012). For example, a face on a plant storage organ can indicate its role as a body, and a sad expression can indicate an effect from damage or suboptimal conditions (Figure 2; Bruni et al., 2018). The compact and rounded belowground bodies of many plants adapted for stressful environments can make cuteness easier to convey and their situations are more dramatic, allowing for lively expressions. Designers frequently take advantage of the shapes and body arrangements very different from humans to make creative and appealing images (Duffy, 2014).

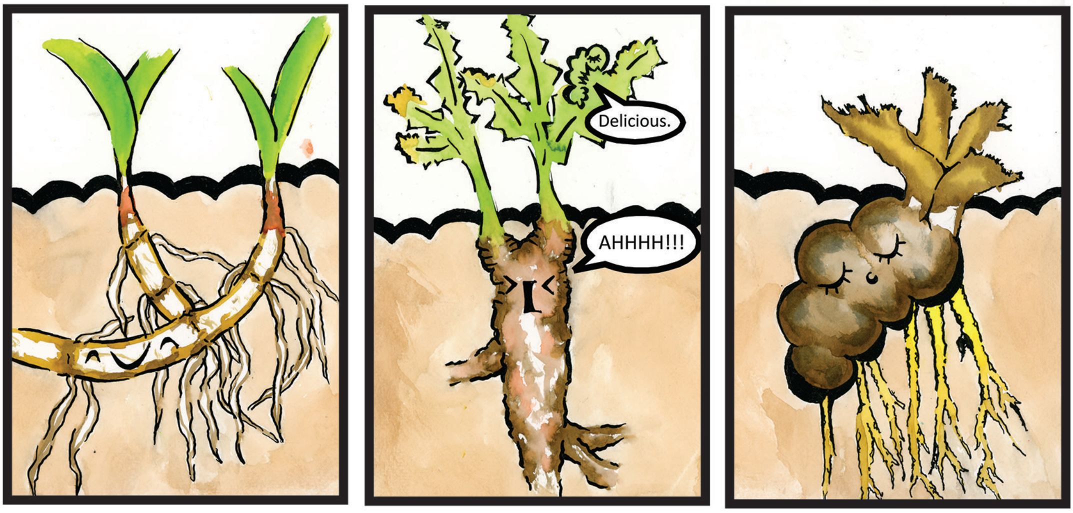


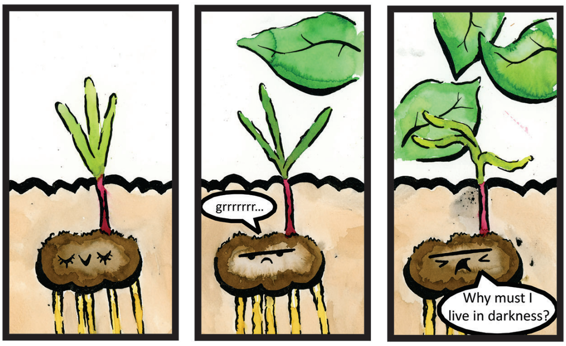
Figure 2. *Plant expressions.*

The Cute Plant Tells Its Story

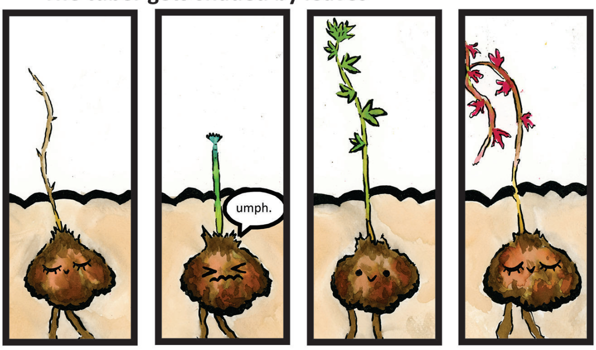
Narrative is another powerful tool to communicate information and increase understanding, which is especially important to explain concepts more distant from the human experience (Negrete and Lartigue, 2004; Dahlstrom, 2014; Lin et al., 2015). Anthropomorphism may aid in forming the subject as a relatable and recognizable character for use within narrative (Farinella, 2018) and bring levity and lightheartedness to a subject to engage the viewer (Yeo et al., 2020). Anthropomorphic features and imagery are also part of pretense/pretending, holding counterfactuals as imaginative play or amusement, commonly used by children to learn and grow (Severson and Woodard, 2018). Anthropomorphism and pretense can increase enjoyment, engagement, understanding, and retention of details for both children and adults (Geerdts et al., 2016; Yeo et al., 2020; McGellin et al., 2021). These tools can also be used to correct possible misconceptions and illuminate obscure topics (Chan et al., 2012), which may be especially useful for understanding perennial herbs because they have a diverse range of belowground storage organs that form their central bodies, all hidden in the soil. By making narratives that include the belowground organs of plants (and their informative traits) and including our own expressive features, we can thus see and relate to the full lives of plants (Figure 3).

Conclusions

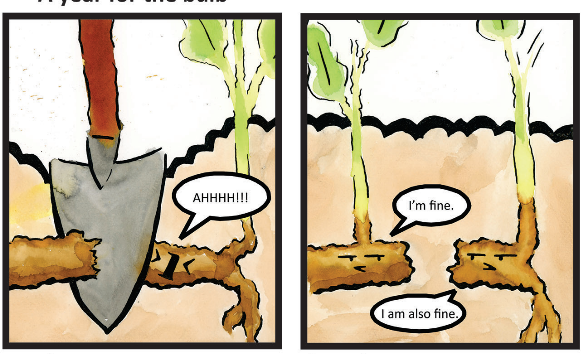
The visual signs of plant functional traits, human expressions, and narratives can all convey information about plant life and be fun at the same time. To learn about the lives of plants, we must dig them up, see these signs both above and below the soil, and show them to people to give greater learning and understanding. Cuteness and narrative are not mandatory, but they can increase understanding and give viewers a more personalized view of how we view plants and the enjoyment we have in our work.



The tuber gets shaded by leaves



A year for the bulb



The rootsprouter meets a shovel

Figure 3. *Plant stories.*

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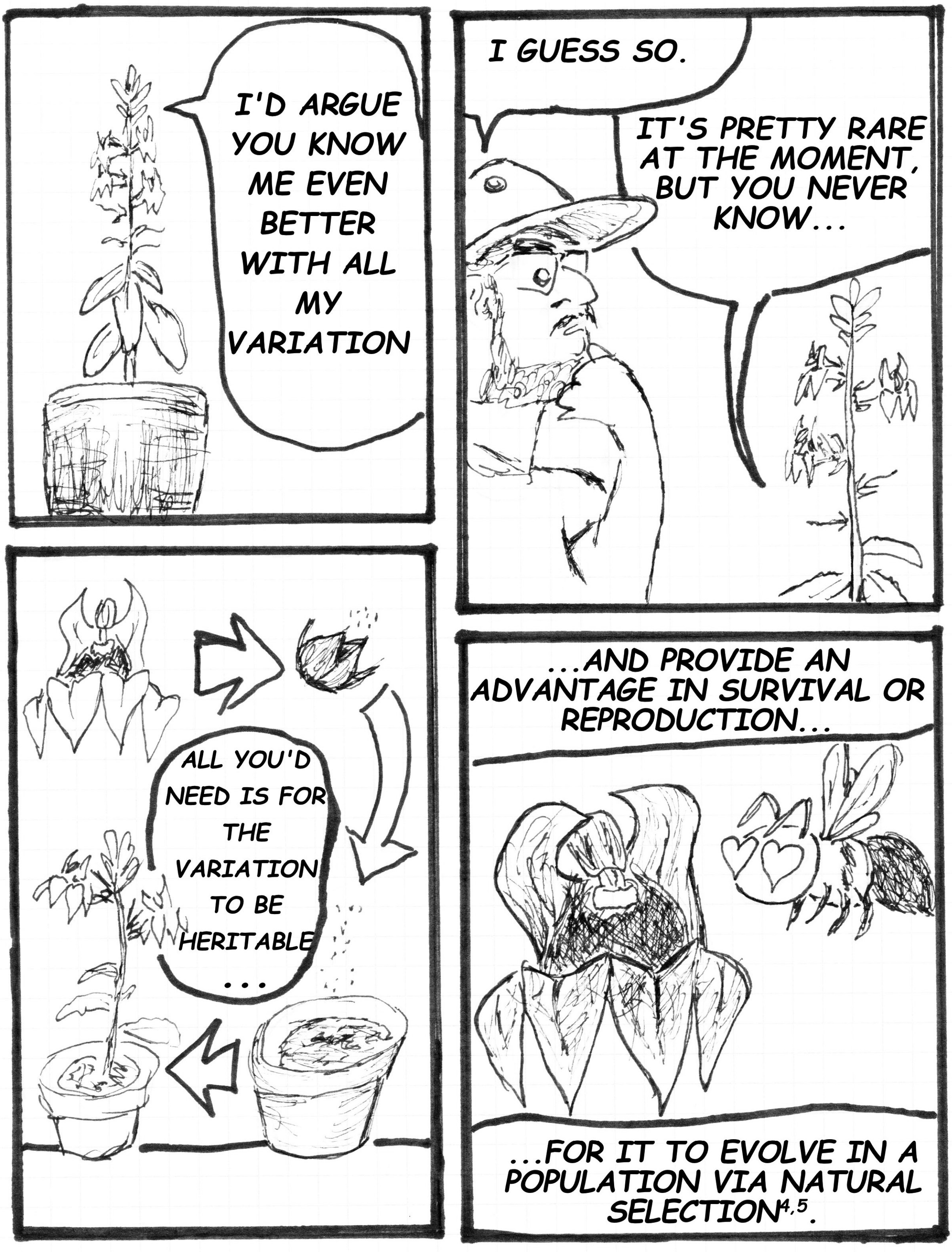
WHY ARE YOU DOING THAT? UNEXPECTED VARIATION IN FLORAL TRAITS OF BLUE CARDINAL FLOWER

BY: GAVIN HOSSACK


HEY, IT'S PERFECTLY NORMAL TO HAVE SOME VARIATION IN PETAL NUMBER.
IT'S COMMON IN OTHER SPECIES[2] AND CAN COINCIDE WITH...
...ABIOTIC FACTORS THAT MIGHT CAUSE STRESS DURING FLORAL DEVELOPMENT[3].
OKAY, I COULD SEE HOW STRESS MAY CAUSE SOME VARIATION.
...BUT YOU'RE ALL STILL BLUE CARDINAL FLOWERS?
I FEEL I DON'T KNOW YOU ANYMORE.


I'D ARGUE YOU KNOW ME EVEN BETTER WITH ALL MY VARIATION
I GUESS SO.
IT'S PRETTY RARE AT THE MOMENT, BUT YOU NEVER KNOW...
ALL YOU'D NEED IS FOR THE VARIATION TO BE HERITABLE...
...AND PROVIDE AN ADVANTAGE IN SURVIVAL OR REPRODUCTION...
...FOR IT TO EVOLVE IN A POPULATION VIA NATURAL SELECTION[4,5].


THIS HAS HAPPENED FOR THE NUMBER OF FLORAL ORGANS IN MANY PLANT FAMILIES[6].
SO THIS VARIATION IS NECESSARY FOR EVOLUTION IN SOME WAYS?
YEP! WOULD YOU LIKE TO SEE SOME OTHER VARIATION? LOOK AT MY STIGMA
OR HOW ABOUT THE FACT YOU'RE TALKING?
SHH... A TALE FOR ANOTHER TIME.
THE END

Gavin Hossack
Port Perry, Ontario Canada

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Wild Growth Paintings

Daniel Philosoph

I am a painter and a graduate of the Bezalel Academy of Art and Design. I have my own studio in Rechovot, Israel, where I paint my personal art. I also do wall paintings, and live painting performances.

The painting shown in Figure 1 is part of a series called substrate, in which I paint visions from a small bowl containing soil fungi and slime mold that I grew. The bowl serves as the central stage for the unplanned wild growths from my pots at home; in this sense, it is a tiny uncivilized jungle

Figure 1. *Daniel Philosoph,* Substrate 6*, oil and acrylic on canvas, 250×180 cm, 2020.*

Figure 2. *Daniel Philosoph,* On the way to Mayan*, oil, acrylic, and spray on canvas, 180×120 cm, 2020.*

growing in my civilized bowl. In this painting I looked through a window of about 2 × 1.5 cm from a side angle that creates a view of a landscape. The observation is done through different macroscopic magnifying glasses, which produces multiple perspectives and focuses on every detail in the painting—a combination of depth and flattening.

The painting shown in Figure 2 is a "far-out." I mean that I treat it like a close-up painting, only in reverse. This is a piece of landscape located at the edge of the city where wild crops have taken over what was once a field/cultivated area and is now abandoned, allowing the wild growth of invasive vegetation. It is a type of an unplanned jungle that reclaims its grip on the ground using leftover remnants. This painting is based on a photo I took with a drone, and it simulates a magnifying-glass view.

In these paintings I look at the wild biology that is at the edge of my existence, the edge of my flowerpot, or my city. These are multi-layered process paintings that try to draw from the visual of the wild biology and create a parallel process of the growth of the painting on the canvas. This is done by breaking down the visual into different actions that represent parts in visibility and structure (the light, the branches, the parasitic plant, the biology that serves as a growing medium, etc.). Each operation uses a certain shade or two, a certain dilution, and a different character. Any such operation is blind, and as soon as its properties are determined, it runs over the painting and rises above the previous layers. The painting is the result of all the processes that took place on the canvas—a kind of biology of a painting.

In my work, I draw inspiration from the way in which science examines biology and describes the processes that take place. This biological information serves me, as a kind of internal, subconscious information that exists in nature and provides me with another perspective on the sights of nature.

Art + Botany: Making a Difference

Kathleen Marie Garness
Scientific affiliate, Field Museum
Science and conservation affiliate, Morton Arboretum

Sometimes a book changes the trajectory of your life. Frederick Case's *Orchids of the Western Great Lakes Region* was that turning point for me. There are 40+ species of orchids in the Chicago region?? What a revelation! But how were they doing now? My son was collecting Boy Scout merit badges at the time, and we used that as an excuse to visit natural areas and look for orchids and to learn more about where they lived. The naturalist leading a tour at Volo Bog told us how she had found a Rose Pogonia (*Pogonia ophioglossoides*) lying on the boardwalk, plucked up and then cast aside. "How could they?!" I thought. A lack of deep awareness and empathy for nature seemed to be commonplace, so was it possible to make a difference somehow? Synchronistic events led to enrollment in Principles and Practices of Rare Plant Monitoring, with Susanne Masi, one of the founders of the North Branch Restoration Project in Cook County, IL, and then co-founder of the Chicago Botanic Gardens' Plants of Concern program. That led to becoming part of the natural area's stewardship and restoration community, then to painting midwestern orchids and teaching others about them.

One dilemma most stewardship volunteers have is identifying the plants in their preserves. How could you tell the invasive species you needed to remove, from the native ones who had evolved there? Field botany is seldom taught in colleges anymore, much less high schools, and popular field guides are incomplete. Most of us had little familiarity with scientific (dichotomous) keys—those were considered the province of the elite botanist. During restoration workdays, experienced stewards would point out a plant, tell us its common and scientific names, with the hope that we would remember them at next encounter. There seemed to be no middle ground between generic botanical guides and exhaustive keys such as those found in *Gray's Manual of Botany* (Fernald, 1950) or Gleason and Cronquist's *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. How can one appreciate and protect biodiversity if one cannot recognize it? How do you shift from seeing masses of vegetation into seeing this dazzling array of plants as friends and companions on your journey who you'd like to get to know better?

Although the iNaturalist app has become increasingly widespread and may help with some identifications, there are many situations where you simply have to use a dichotomous key and invest the time and work in order to learn how to do it. Admittedly, that is an advanced step. Can there be a middle ground that is scalable?

Twelve years ago, Cook County steward Barbara Birmingham asked me to help her develop some illustrated plant family pages for her volunteers. Collaborations with professional botanists and ecologists were necessary so the pages could be both accurate and succinct. Other pages followed. The Field Museum offered to publish them, seeing they met a wider need to learn about our diverse flora here in the Chicago region. The free download, *Common Plant Families of the Chicago Region*, introduces students to 23 regional plant families, including examples of non-native invasive species that threaten remnant ecosystems. Other guides followed, including an illustrated glossary to the regionally respected *Flora of the Chicago Region* as well as several other genus-level treatments published by Conservation Research Institute. There are so many features covered in dichotomous keys, it is important to have a visual reference for when you run into a new term. And there is really no substitute for that level of study, nor should there be. Working with *Flora of the Chicago Region* co-author Dr. Gerould Wilhelm and other botanists taught me that to draw plants accurately, you first must take time to observe them very carefully, then read the keys carefully, drawing only what is essential to see how that species differs from those similar. I worked primarily from herbarium material.

With over 7000 downloads by 2019, Common Plant Families of the Chicago Region was showing its usefulness. The joint Chicago Botanic Garden/ Northwestern University masters and doctoral programs, the University of Illinois Master Naturalists' program, the Forest Preserves of Cook County, and local restoration contractors continue to use it to train students, staff, and interns. As of June 2023, the guide has been translated and downloaded 13,826 times in the English version, 4831 times in Spanish, and 172 times in Portuguese.

Speaking recently with a colleague tasked with hiring ecologists for a regional forest preserve program, she recounted how many applicants with Masters degrees in ecology knew only a few native plants and their plant community associates, and appeared flummoxed when asked what they knew about plant taxonomy. This lack of plant knowledge is disqualifying them for good jobs in the profession. The situation is even worse in the growing field of natural areas restoration contractors, who need to know the difference between the native Purple Prairie Clover (*Dalea purpurea*) and purple Blazing Stars (*Liatris* spp.) from the non-native, invasive Purple Loosestrife (*Lythrum salicaria*), and who are set loose with chemicals and only rudimentary training in plant identification. This ought to be avoidable, but I hear this story again and again. It is our hope these guides and others will make a difference.

Another question surfaced: how do we reach out beyond our rather insular, aging, community of well- educated people, mostly of European-American descent, involved with botany and natural areas restoration work? How about through art? Art is a universal language. In 2013 the American Society of Botanical Artists funded our project to bring botanical illustration to new and diverse audiences, supplying materials to over 70 students of all ages, ethnicities, and abilities, in ten regional venues: nature centers, forest preserves, and nature museums. In 2022 they funded our research based around Illinois Beach State Park, to document and illustrate the 23 species of orchids identified there from herbarium records. The Volunteer Stewardship Network of the Illinois Nature Conservancy provided funding for more art materials for three children's classes, one for teens, and two for adults in Zion and Waukegan, IL, where almost 50% of the residents' primary language is Spanish.

Art is a way of seeing things more deeply and clearly. In order to draw a plant accurately, you need to study all its parts, observe it from all angles, touch it, smell it, and develop a relationship with it. Old botany textbooks featured drawing plant parts at each level of the curriculum. We hope to recapture some of the wonder and curiosity of

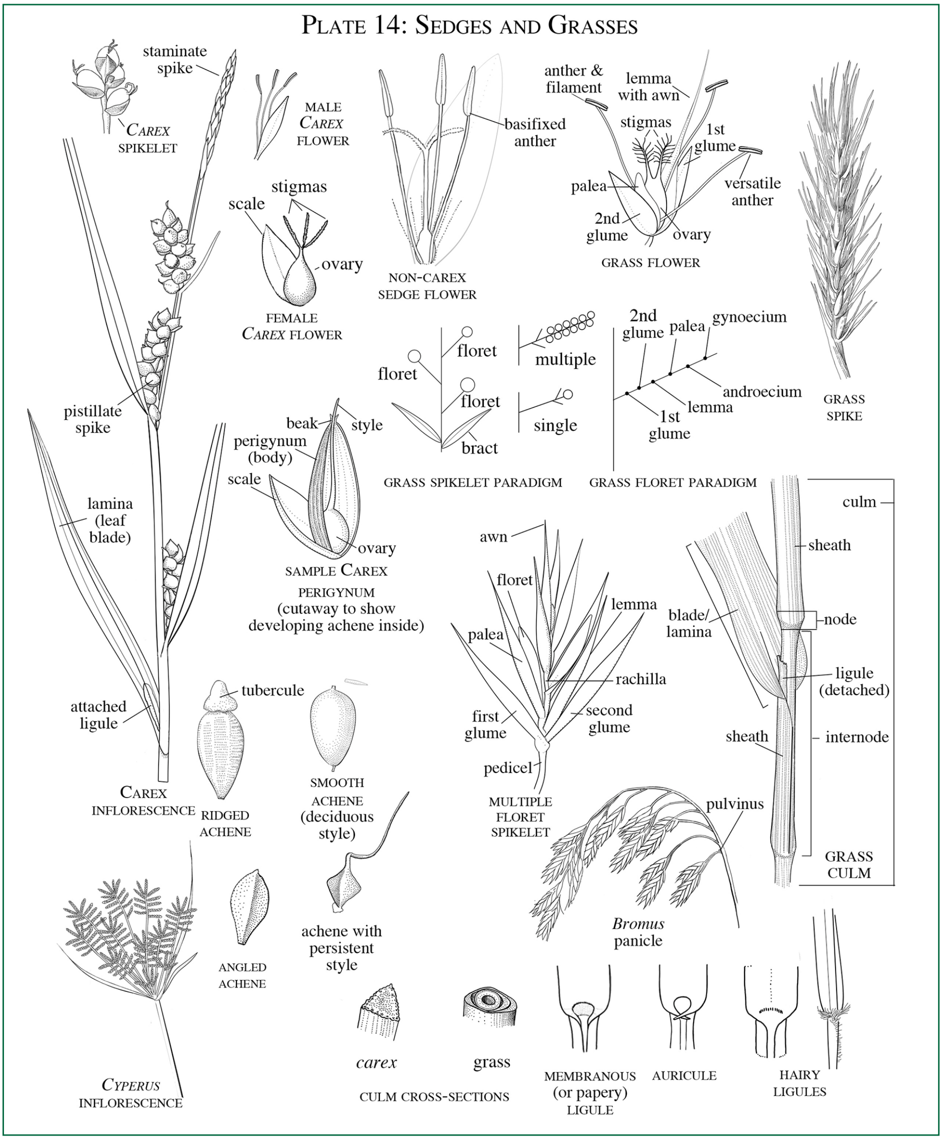


Figure 1. *Sedges and grasses.*

childhood in each of these lessons, to help others experience the beauty and complexity of the plant world and find inspiration in it.

There is a spiritual thread in all of this—a quest to find meaning and beauty in the world, to deeply engage with our native flora. We know that nature is a refuge for our spirits; during COVID, people flocked in droves to the forest preserves and other natural areas, in visitation numbers not seen in many years. But do the visitors make the connection between how they feel out in nature with nature's pressing need for compassionate stewardship? The goal of my art, therefore, and especially the teaching of botanical art, is to engage people with plants—to see them more precisely, to learn the language of botany, and to identify and describe what they see. And learn to care for them and participate in millennia-long human-cultural relationships that will benefit all of us.

REFERENCES

Fernald, M. L. 1950. *Gray's Manual of Botany,* ed 8. Dioscorides Press: Portland, OR. 1632 pp.

Botanical Society of America's Award Winners (Part 2)

Distinguished Fellows of the Botanical Society of America

The "Distinguished Fellow of the Botanical Society of America" is the highest honor our Society bestows. Each year, the award committee solicits nominations, evaluates candidates, and selects those to receive an award. Awardees are chosen based on their outstanding contributions to the mission of our scientific Society. The committee identifies recipients who have demonstrated excellence in basic research, education, public policy, or who have provided exceptional service to the professional botanical community, or who may have made contributions to a combination of these categories.

Dr. Thomas Givnish

University of Wisconsin-Madison

Dr. Thomas Givnish is an internationally renowned scientist who is acclaimed for his "sharp intellect, breadth of knowledge, creativity, and productivity." He is known for his unique interdisciplinary research and for his breadth of expertise, making major contributions to such diverse areas as ecophysiology, systematics, biomechanics, plant-animal interactions, adaptive radiation, and species diversification and extinction. Over the past 51 years, Tom has authored, coauthored, or edited more than 160 papers, books, and book chapters, which have been cited more than 21,000 times. *And* he has sustained substantial funding from the National Science Foundation to support his research for many years.

Tom has made foundational contributions in the fields of ecology and systematics: "his work on the evolution of monocots, bromeliads, and carnivorous plants, among other groups, has been equally as transformative as his experimental and theoretical studies on plant functional traits, plant height, leaf form, and photosynthetic physiology." Tom's early work in plant ecology was grounded in his keen interest and background in mathematics and economics. He developed mathematical models inspired by economic theory to explore and explain the adaptive nature of leaf form and plant height. He was an early adopter of molecular techniques for studying ecology and evolution, and he blended his work on adaptation with phylogenetic resources, applying the concept of adaptative radiation to plants. His 1997 book *Molecular Evolution and Adaptive Radiation*, co-edited with Ken Sytsma, remains authoritative. His work in phylogenetic systematics, and his embrace of new methods and approaches, has kept him at the forefront of developments in the field. Tom's focus on monocots has transformed our understanding of the evolutionary history and higher-level relationships of that group. And he's showing no signs of slowing down.

Tom has immense and infectious enthusiasm for both fieldwork and the lab, and his knowledge of plant diversity, natural history, and ecology is encyclopedic and insightful. He shares his knowledge and passion for plants with his students and colleagues and reaches beyond the University as well through the "Wednesday Night @ the Lab" televised outreach talks, presentations to naturalist and gardening groups, and engagement with local conservation groups. He is also involved in the DNR Citizens Advisory Board for Wisconsin Dells Natural Area and the U.S. Fish & Wildlife Service National Recovery Team for the Karner Blue butterfly. He is a botanist well-deserving of the BSA Distinguished Fellow Award.

Dr. Steven Manchester

Florida Museum of Natural History

Dr. Steven Manchester is one of the world's leading specialists in fossil plants, whose research has had "a profound impact on the directions in the scientific exploration of angiosperm diversification and biogeographic patterns, particularly through the Cenozoic." Through extensive field work throughout the world, including in the western US, eastern Asia, India, Europe, and Panama, and through careful study, he has documented some of the earliest known fruits for several families of flowering plants, including the banana (Musaceae), kiwi (Actinidiaceae), grape (Vitaceae), and walnut (Juglandaceae) families. Dr. Manchester often works at the "interface of the living and the dead, working closely with angiosperm systematists to integrate fossils into phylogenetic trees of living species." He also has worked with molecular systematists to provide fossil calibration points for molecular dating analyses. His broad network of international collaborations has included researchers from all career stages and backgrounds, and he is known to be generous with his time and ideas.

In addition to his impressive publication record, his many invited presentations and research grants from NSF and other funding sources, Steve has also been deeply engaged in public outreach engaging amateur collectors and students in his field campaigns. He is described by several colleagues to be hard-working, with a passion for field work, which he considers essential to paleobotanical research. He is also described as kind, thoughtful, modest, having a great sense of humor, and intensely dedicated to student training and mentorship.

Steve is a life member of both the Botanical Society of America and the American Society of Plant Taxonomists. He has held leadership roles in the Paleobotanical Section of BSA and the International Organisation of Palaeobotany (IOP), in which he served as President for many years. He is a Foreign Representative Member of The Gondwana Geological Society based in Nagpur, India, and is active in the Association of Wood Anatomists and the American Association of Stratigraphic Palynologists. He has served on his department's Natural History Advisory Committee and chairs his institution's IDEA (Inclusion, Diversity, Equity, and Accessibility) Committee, which recently developed an endowed scholarship fund for graduate students of minoritized groups and an internship program for students from groups that are underrepresented in science in the US. He is a great model for service to the professional community and well deserving of the BSA's Distinguished Fellow Award.

BSA CORRESPONDING MEMBERS AWARD

Corresponding members are distinguished senior scientists who have made outstanding contributions to plant science and who live and work outside of the United States of America. Corresponding members are nominated by the Council, which reviews recommendations and credentials submitted by members, and elected by the membership at the annual BSA business meeting. Corresponding members have all the privileges of life-time members.

Dr. Gonzalo Nieto Feliner, Royal Botanical Garden of Madrid

AWARDS FOR ESTABLISHED SCIENTISTS GIVEN BY THE SECTIONS

CONTRIBUTIONS TO PALEOBOTANY AWARD

Paleobotanical Section

Ruth A. Stockey, Oregon State University

EDGAR T. WHERRY AWARD

Pteridological Section and the American Fern Society

The Edgar T. Wherry Award is given for the best paper presented during the contributed papers session of the Pteridological Section. This award is in honor of Dr. Wherry's many contributions to the floristics and patterns of evolution in ferns.

Katelin Burow, Purdue University, For the Presentation: Genetic Mechanisms of Sex Determination in *Ceratopteris richardii*. Co-authors: Grace Estep, Brian Dilkes, Jody Banks, Jen Wisecaver.

Sonia Molino, Universidad Complutense de Madrid, For the Presentation: Discovering *Parablechnum*: a complex evolutionary history within the youngest fern family. Co-authors: Weston Testo, Mario Mairal, Guillermo Santos-Rivilla, Rafael Medina

MARGARET MENZEL AWARD

Genetics Section

The Margaret Menzel Award is presented by the Genetics Section for the outstanding paper presented in the contributed papers sessions of the annual meetings.

Lauren Frankel, University of Wisconsin-Madison, For the Presentation: Summary tests of introgression are highly sensitive to rate variation across lineages. Co-author: Cécile Ané

MICHAEL CICHAN PALEOBOTANICAL RESEARCH GRANT

Paleobotanical Section

The Award is to provide funds for those who have completed a PhD and are currently in a post-doctoral position or non-tenure track position.

Ana Andruchow-Colombo, University of Kansas, For the Paper: Placing the Voltziales: A study of the origin and evolution of modern conifers.

Michael D'Antonio, Field Museum, For the Paper: Reconstruction and systematics of conflictive late Paleozoic plants using tomography and microphotography on Mazon Creek nodules and coal balls.

AWARDS FOR STUDENTS
THE BOTANY AND BEYOND: PLANTS GRANTS RECIPIENTS

The PLANTS (Preparing Leaders and Nurturing Tomorrow's Scientists: Increasing the diversity of plant scientists) program recognizes outstanding undergraduates from diverse backgrounds and provides travel grant.

Nico Andrade, University of Florida, Advisor: Drs. Pam and Doug Soltis

Sofia Baez, Old Dominion University, Advisor: Lisa Wallace

Cari DeCoursey, Weber State University, Advisor: Dr. James Cohen

Fitzwilliam Dettmer, Rutgers University New Brunswick, Advisor: Dr. Lena Struwe

Natalie Heaton, University of Florida, Advisor: Lucas Majure

Chinyang Huang, Purdue University, Advisor: Dr. Daniel Park

Anij Mackey, Texas Tech University, Advisor: Matthew G. Johnson

Marife Minaya, California State Polytechnic University, Pomona, Advisor: Carrie Kiel

Hashel Orquiz, University of Texas at El Paso, Advisor: Dr. Michael Moody

HeavenLee Pagan, Auburn University at Montgomery, Advisor: Dr. Vanessa Koelling

Dominique Pham, University of Richmond, Advisor: Dr. Carrie Wu

Ethan Richardson, University of Pittsburgh, Advisor: Tia-Lynn Ashman

Tajinder Singh, Mississippi State University, Advisor: Dr. Ryan Folk

Isabella Soto, Auburn University at Montgomery, Advisor: Dr. Vanessa A. Koelling

Trinity Tobin, SUNY Cortland, Advisor: Elizabeth McCarthy

AWARDS FOR STUDENTS GIVEN BY THE SECTIONS

STUDENT PRESENTATION AND POSTER AWARDS

A. J. SHARP AWARD

ABLS/Bryological and Lichenological Section

This award is given for the best student paper presented in the Bryological and Lichenological sessions.

Blair Young, Rutgers University, For the Presentation: A Potential Symbiosis of Nitrogen Fixing Bacterial Endophytes and Their Bryophyte Hosts. Co-authors: Nicole Vaccaro, Lena Struwe, James White

ECONOMIC BOTANY SECTION - BEST STUDENT CROPS AND WILD RELATIVES POSTER

Uzezi Okinedo, University of Massachusettes Boston, For the Poster: Discovering the Genetic Basis of Rice Grain Shape. Co-authors: Dr. Annarita Marrano, Dr. Brook Moyers

EMANUEL D. RUDOLPH AWARD

Historical Section

Ryan Schmidt, Rutgers University, For the Presentation: Hidden Cargo, Death, Survival, and Dispersion of Ballast-Associated Plant Species in the Northeastern USA. Co-authors: Megan King, Jacquelyn Johnston, Myla Aronson, Lena Struwe

ECOLOGICAL SECTION STUDENT PRESENTATION AWARDS

Bess Bookout, Kansas State University, For the Presentation: Bison wallows bolster plant diversity and semi-aquatic habitat in tallgrass prairie. Co-author: Zak Ratajczak.

Maya Shamsid-Deen, University of New Mexico, For the Presentation: The Little Mustard That Could: Is Phenotypic Plasticity Associated with Colonization Success in *Arabidopsis thaliana*. Co-author: Kenneth Whitney

ECOLOGICAL SECTION POSTER AWARDS

Helena Mieras, University of New Mexico, For the Poster: Management Short-Term Implications on *Lupinus perennis*, Duff, and Supporting Vegetation in the Concord Pine Bush. Co-authors: Jennifer Rudgers, Cooper Kimball-Rhines, Heidi Holman

Amber Stanley, University of Pittsburgh, For the Poster: Historical climate change shifts flower shape and production of a common annual plant, Orange Jewelweed (*Impatiens capensis*). Co-author: Tia-Lynn Ashman

ISABEL COOKSON AWARD
Paleobotanical Section

Established in 1976, the Isabel Cookson Award recognizes the best student paper presented in the Paleobotanical Section.

Jeronimo Morales Toledo, University of Michigan, For the Presentation: Reexamination of *Arthmiocarpus Hesperus* from the Late Cretaceous of South Dakota: Expanding the fossil record of bisexual climates in Araceae. Co-author: Selena Smith

KATHERINE ESAU AWARD
Developmental and Structural Section

This award was established in 1985 with a gift from Dr. Esau and is augmented by ongoing contributions from Section members. It is given to the graduate student who presents the outstanding paper in developmental and structural botany at the annual meeting.

Yesenia Madrigal, Universidad de Antioquia, For the Presentation: Assessment of the flowering genetic regulatory network in tropical orchids with different lifeforms. Co-authors: Michael Scanlon, Marian Bemer, Lena Hileman, Natalia Pabón-Mora

LI-COR PRIZE
Physiological Section

Each year, the Physiological Section presents the Li-COR prize to acknowledge the best presentation made by any student, regardless of subdiscipline, at the annual meeting. The Li-COR prize is presented annually at the BSA Awards Ceremony.

Best Student Oral Presentations

Spencer Roop, Idaho State University, For the Presentation: Quantifying genetic variation in physiology and functional traits in subspecies of big sagebrush (Artemisia tridentata) in a common garden setting. Co-authors: Keith Reinhardt, Matthew Germino, Bryce Richardson

Best Student Poster

Leigha Henson, Appalachian State University, For the Poster: Light and Moisture Content as Determinants of Photosynthetic Activity in Southern Appalachian Mosses from Open and Shaded Habitats. Co-author: Howard Neufeld

MAYNARD MOSELEY AWARD

Developmental & Structural and Paleobotanical Sections

The Maynard F. Moseley Award was established in 1995 to honor a career of dedicated teaching, scholarship, and service to the furtherance of the botanical sciences. Dr. Moseley, known to his students as "Dr. Mo", died Jan. 16, 2003 in Santa Barbara, CA, where he had been a professor since 1949. He was widely recognized for his enthusiasm for and dedication to teaching and his students, as well as for his research using floral and wood anatomy to understand the systematics and evolution of angiosperm taxa, especially waterlilies. (PSB*, Spring, 2003). The award is given to the best student paper, presented in either the Paleobotanical or Developmental and Structural sessions, that advances our understanding of plant structure in an evolutionary context*

Madison Lalica, California Polytechnic University, Humboldt, For the Presentation: Probing the origin and evolution of periderm: what can extant plants and the fossil record tell us? Co-author: Mihai Tomescu

PHYSIOLOGICAL SECTION STUDENT PRESENTATION AND POSTER AWARDS

Best Student Oral Presentation

Steven Augustine, University of Wisconsin, For the Presentation: Life at the extreme: understanding how hydraulics constrain some of the longest living pines to unique elevational positions. Co-author: Katherine McCulloh

Best Student Poster

Katherine Charton, University of Wisconsin - Madison, For the Poster: An encroaching woody species (Cornus racemosa) does not alter gas exchange in response to drought as much as the dominant herbaceous species in a managed temperate grassland. Co-authors: Steven Augustine, Ellen Damschen

PHYTOCHEMICAL SECTION PRESENTATION AWARDS

Best Student Oral Presentation:

Evin Magner, University of Minnesota, For the Presentation: Post-secretory synthesis of a natural analog of iron-gall ink in the black nectar of *Melianthus* spp.

Best Student Poster:

Jayani Wathukarage, Rice Research and Development Institute, Sri Lanka, For the Poster: Phytochemical compounds from Eucalyptus with herbicidal activity

Applications in Plant Sciences Celebrates Its 10th Anniversary

2023 marks 10 years of publication for *Applications in Plant Sciences*, the BSA's open access methods journal. To celebrate this milestone, the *APPS* staff has collected 25 articles spanning the history of *APPS* and highlighting the breadth and depth of the journal's portfolio. The featured articles are just a few examples of the protocols, software, and genomic resources that have established *APPS* as a destination for methods in plant biology, with a new impact factor of 3.6. We thank our editors, reviewers, authors, and readers for making this growth and success possible.

Enjoy this collection of *APPS* articles at https://bit.ly/46TpeWB and consider submitting your novel technique, software, or review to *APPS* in the future. The BSA looks forward to the next 10 years of innovation and service to our authors and readers.

BOTANY 2023
AT A GLANCE

"I loved seeing students and scholars from so many different cultural backgrounds come together and thrive."

1040 NUMBER OF ATTENDEES:
43% STUDENTS
7% POSTDOCS
50% PROFESSIONALS & OTHER

2ND HYBRID CONFERENCE

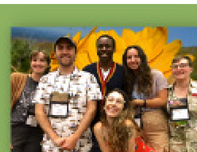
11% VIRTUAL
89% IN PERSON

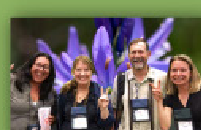
33 COUNTRIES
49 US STATES AND DC

"I had a great time at Botany 2023. It continues to be an **extremely friendly and supportive conference experience**."

- **8** Special Lectures
- **6** Symposia
- **6** Colloquia
- **440** Oral Presentations
- **253** Posters
- **10** Mixers / Receptions / Luncheons
- **12** Workshops
- **18** Lightning Talks
- **11** Field Trips

Highlights





- **Affinity Groups** including:
  - Botany Scoop: Alcohol-free Ice Cream Social
  - Asian, Asian American and Pacific Islander Mixer
  - Disabled in the Botanical Sciences Meetup
  - LGBTQ Gathering
  - Indigenous Voices Gathering
- **Botanical Bingo** during the Lightning Talks
- **Green-Screen Photo Booth**
- **Botany & Dragons** - D&D Night
- **2 Botany in Action Projects**

"It was a great experience, I really enjoyed my **field trip**, **learned about careers** at the luncheon, **networked with many of the career panelists**, **presented research**, **learned about so many amazing research projects** and more! A very great experience!"

Some Scenes from Botany 2023!

I had a great time at Botany 2023. It continues to be an extremely friendly and supportive conference experience.

This was the first "normal" Botany conference since COVID and
I liked the energy people had.

By far, Botany remains one of the best scientific meetings I attend regularly

It was nearly back to "normal"
and, boy, did I need that.

California Botanists Brown Bag Lunch!

Thank you for all
the coffeeeee!!!!

I perceived the conference as a welcoming and respectful environment where everybody had a chance to participate and discuss science. I loved seeing students and scholars from so many different cultural backgrounds come together and thrive. I especially liked the breakfast time and the celebration at the end, they were wonderful opportunities to connect with colleagues and meet new

In grad school I attended another scientific conference and went back for the first time this year - I realized how much more enjoyable Botany is and that will be my main plant conference in future years. Keep doing what you're doing, it's a wonderful community!

I thought this was a great conference. There were tons of interesting talks, and the poster session was well attended.

BSA Spotlight Series

The BSA Spotlight Series highlights **early-career scientists** in the **BSA community** and shares both scientific goals and achievements, as well as personal interests of the botanical scientists, so you can get to know your BSA community better.

Here are the latest Spotlights at https://botany.org/home/careers-jobs/careers-in-botany/bsa-spotlight-series.html:




- Trinity Depatie, Graduate Student, University of South Carolina
- Adriana I. Hernandez, Postdoctoral Fellow, California Academy of Sciences
- Matias Köhler, Postdoctoral Fellow, São Carlos University (UFSCar), São Paulo, Brazil
- Jesús Martínez-Gómez, Postdoctoral Fellow, University of California, Berkeley

Would you like to nominate yourself or another early career scientist to be in the Spotlight Series? Fill out this form: https://forms.gle/vivajCaCaqQrDL648.

By Amelia Neely

BSA Membership & Communications Manager

E-mail: ANeely@botany.org

BSA PROFESSIONAL HIGHLIGHT SERIES

This year, we are including a **BSA Professional Member Highlights** section each month in the *Membership Matters* newsletter. If you would like to be highlighted, email Amelia Neely at aneely@botany.org.

Keri Maricle

Life Sciences Instructor, Adjunct, at Barton Community College

LinkedIn:
https://www.linkedin.com/in/kerimaricle/

Keri is a biologist and educator with experience teaching K-12 and college-level courses in the life sciences. Currently, Keri is working on a psychology degree with research focused on LGBTQ+ inclusion and sense of belonging in STEM education.

Dr. Jordan Metzgar

Curator of the Massey Herbarium (VPI), Department of Biological Sciences, Virginia Tech

X (formerly Twitter):
https://twitter.com/MasseyHerbarium

Dr. Metzgar received his B.S. in biology from Cornell University and earned his Ph.D. from the University of Alaska Fairbanks for his dissertation on the evolution of the parsley ferns (*Cryptogramma*). His current job involves researching the ecology of various southeastern U.S. plants and running an active STEM outreach program in the local community. He became entranced by ferns when he was an undergraduate, and his favorite plant is walking fern (*Asplenium rhizophyllum*).

NEW BSA AWARD! AJ HARRIS GRADUATE STUDENT RESEARCH AWARD

We are very excited to share that, thanks to the generous support of over 70 donors, the Society has established an **endowed fund to support an annual graduate student research award in memory of AJ Harris.** The online portal for applications will open in a few months. Learn more about AJ, see a list of donors, and read the Memory Wall at https://botany.org/aj-harris-memorial.html.

We want to show our appreciation to AJ's friends and family for helping us fulfill the goals in our strategic plan by supporting students and botanical research. To discuss the ways in which you can support the Society through endowed gifts, please email BSA Executive Director Heather Cacanindin at hcacanindin@botany.org.

BSA STUDENT CHAPTER UPDATES AND EVENT

Help us to welcome to the new BSA Student Chapters:

- Botanical Society of St. Cloud State University
- The Gustavus Botanical Society

This is a reminder to **BSA Student Chapters' officers** about the **upcoming deadline of December 31, 2023**, for the following items:

- Chapters will need to **fill out the event form at https://bit.ly/3rVSe18 for at least two events for 2023**. This will include a description of the event, possible photos of the the event plus captions, the number of people who attended, and if you would like us to share your event with the BSA community.
- BSA Student **Chapter Presidents and Secretary/Treasurers will have to have a current BSA membership.** This means if your current membership expires in 2023, you will need to renew it by December 31, 2023. Student chapter members have a discounted membership costing just $10. **We encourage all student chapter members to have a BSA membership.** Financial aid is available by emailing aneely@botany.org.
- This is a great time to start thinking about your leadership for the next year and to have an election if needed. Please send any leadership changes to aneely@botany.org as they become

available. New leadership in the President and Secretary/Treasurer positions will be required to be a current BSA member for 2024 by December 31, 2023, or when they are elected if after that date.

If you want to see the full list of BSA Student Chapters, or learn how to start a chapter at your institution, go to https://botany.org/home/membership/student-chapters.html.

IT IS RENEWAL SEASON!

Thank you for your current BSA membership support! BSA provides annual memberships that run from January to December of each year. October is the start of our membership renewal season, so if your membership expires in 2023, you should have started getting renewal notices since early October.

Please note the following changes starting October 1, 2023:

- One-Year Affiliate Memberships will increase by $5, totaling $55.
- One-Year Student Memberships will increase by $5, totaling $25. Three-Year Student Memberships will increase by $10, totaling $60.
- One-Year Student and Developing Nations' Gift Memberships will increase by $10, totaling $20. Three-Year Gift Memberships will increase by $25, totaling $55.

While renewing, you can also renew **your sectional affiliations**, **donate to the BSA endowment, award funds, and section award funds**, **purchase gift memberships, and purchase a print subscription of the *Plant Science Bulletin* (see below)**. If you are not due to renew this year, we hope you will consider donating to BSA and giving gift memberships during the fourth quarter.

To renew your membership, go to https://crm.botany.org. If you do not need to renew, please consider donating to BSA funds, or purchasing gift memberships, go to https://crm.botany.org.

PLANT SCIENCE BULLETIN PRINT SUBSCRIPTION CHANGE

Starting with the Spring 2024 issue of the PSB, **print copies will require a $10/year subscription that will run from January to December of each year and will include the three issues for that year.**

Subscriptions are now available for 2024 **when you renew your membership.** Members who do not need to renew will be able to purchase a subscription by going to https://crm.botany.org/ and choosing the corresponding menu option.

YEAR-END GIVING

BSA is proud to provide over $120,000 in awards and grants to our members every year. Most of these are funded **directly by the generosity of our members** via donations to specific award funds. We hope that you will consider making a donation to our many funds including student, professional, and sectional award funding when you renew your membership this year. You can also visit www.botany.org and click Donate to start giving right now.

Professional members are given the opportunity of increasing their annual dues by $25 in order to support the Graduate Student Research Award fund. Together with GSRA donations, over $32,202 in additional funds were raised for the GSRA in the last fiscal year and 31 GSRA awards were able to be given in 2023. Thank you to all of our members who made this possible.

The **Endowment Fund** and the **Unrestricted Fund** both have very important roles in the stability and longevity of BSA. We hope you will consider making donations to these funds when choosing your year-end donation plans. Donations to these funds are being used to move BSA into the future, and to support our global community like never before.

Want an even more lasting way to support BSA? Consider joining the **Legacy Society**. To learn more about the society see our latest Legacy Society email by going to https://mailchi.mp/botany.org/bsa-legacy-society-2022-dr1 or visit our Legacy Society web page at https://botany.org/home/membership/the-bsa-legacy-society.html.

2023 BSA GIFT MEMBERSHIP DRIVE *HELP US GET TO 175 GIFT MEMBERSHIPS*!

The 2023 Gift Membership Drive has begun! This year our goal will be 175 gift memberships through December 31, 2023! BSA Gift Memberships are a great way to introduce students and developing nations' colleagues to the BSA community. You can purchase one-year ($20) or three-year ($55) gift memberships by visiting https://crm.botany.org and choosing "Give a Gift of Membership".

Don't have anyone specific for whom to purchase a gift membership? Not a problem! You can put an "X" in the gift membership recipient fields and we will make sure they get to those students and developing nations' colleagues who need financial assistance. Questions about gift memberships or other ways to donate? Email Amelia Neely at aneely@botany.org.

We are giving back! Any gift membership recipient who starts their membership before January 31, 2024 **will be entered into a drawing for a free registration for Botany 2024**!

NEW BSA AD HOC COMMITTEES

Thank you to everyone who applied to be on the Ad Hoc Committee on Climate Change, Membership Ad Hoc Committee, and the Ad Hoc Committee for AI and Publications. We appreciate the time and effort taken by those who did not get chosen and hope that you will consider applying for open committee positions as they become available in the Fall.

To see the new committee members, go to https://botany.org/home/governance/committees-committee-officers.html.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POCKET SCIART GUIDES TO PLANT FAMILIES
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FROM THE *PSB* ARCHIVES

60 years ago

Albert Robinson Jr. from Kansas Wesleyan University discusses research collaborations with Mexican universities.

"In very recent years an increased emphasis has been placed upon botanical research in tropical areas. Expanding populations and rapidly developing industries are placing increased pressure on the existing undisturbed lands. A sense of urgency has arisen to study and record the biota of these areas before they are irrevocably altered by man's quest for a better life. In this respect, our neighbor to the south, the Republic of Mexico, offers an excellent opportunity for North American botanists to assist in this important task, and to work in a tropical region of high botanical importance which is rapidly being affected by industrialization."

-Robinson Jr., Albert. 1963. Botany in Mexican Schools. PSB *9(3): 6-7*

50 years ago

"At the annual meeting of the Society at Amherst in June, the Council authorized the establishment of an endowment fund, the income of which will be used to subsidize the publication of papers in the *American Journal of Botany*, and other publications of the Society written and submitted by students. Immediately upon the establishment of the Endowment Fund a total of $350 was pledged to the fund from among members of the Council."

-Endowment Fund Started. 1973 PSB *19(3): 40*

40 years ago

"The Teaching Section's Slide Exchange Program was again very successful and will be continued and expanded. During the past year over 2500 color transparencies were duplicated for society members."

-Teaching Section Slide Exchange Program. 1983. PSB *28(5): 35.*

SCIENCE EDUCATION

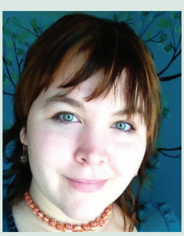
Updating BSA's State-by-State Botanical Resource Pages Please Help!

Have you ever had an undergraduate student or other early-career botanist leave the area(s) you know best to pursue their botanical interests in another state? Do you wish you could easily provide them with the best, most up-to-date flora or field guide for their new location? Or have you ever been asked where someone could find a degree program in botany or a botanically focused organization outside of your location?

The BSA Education Committee is seeking to update the state-by-state resource lists available on the botany.org website by crowdsourcing from BSA's knowledgeable members. We're looking for information about up-to-date floras and field guides, academic programs (where in your state can people pursue a botany-related degree?), as well as organizations and quality, durable web resources focused on the botany of the state or region. To start, we are focusing on U.S. states and territories, but we may expand this project to cover other regions where BSA members live and work if this project is successful and members find the information useful.

To submit a resource, please use this link: https://forms.gle/VjpHPYM9pVKJ4dmh9

Together, we can build a valuable reference list that will help botanists and aspiring botanists orient to high-quality botanical resources of states and territories with which they are not already familiar. It should take less than 5 minutes to submit your resource(s), which will be vetted by the Education Committee and then added to the botany.org website. Thank you very much for your help with this low-lift but (hopefully) high-value project!




By Dr. Catrina Adams, *Education Director*

Jennifer Hartley, *Education Programs Supervisor*

PLANTINGSCIENCE UPDATES

Summer and Fall of 2023: F2 Research is Underway

The PlantingScience team has been working at full tilt this session! With more than 40 teachers signed up between our current F2 research participants and our returning teachers from previous years, we are having to keep more plates spinning than usual.

Fortunately, we had a great summer of professional development workshops. We had 21 teachers and 15 scientists take part in our in-person workshops in Colorado Springs and St. Louis, and another 18 teachers and 14 scientists participate in online training via Zoom. These trainings introduced participants to the activities that comprise our Power of Sunlight investigation theme, which focuses on photosynthesis and cellular respiration, and gave them an opportunity to experience online "mentoring" as teachers designed their own exploration with support from their scientist partners.

In addition, we have 18 teachers who are acting as a control group this session, teaching the same topics using their usual curriculum and activities. These teachers will be included in workshops during summer of 2024 and will use PlantingScience with students during the Fall 2024 session.

MEET OUR 2023 F2 FELLOWS!

Please join us in welcoming and congratulating the early career scientists who are participating in the F2 research work this session:

Abdulkabir Abdulmalik
Hannah Assour
Israel Borokini
Meghan Britton
Jessica Carstens-Kass
Snehanjana Chatterjee
Cael Dant
Natalie Dietz
Kasia Dinkeloo
Chloe Fackler
Josh Felton
Melinda Findlater
Julie Gan
Audrey Geise
Kajal Ghoshroy
Devani Jolman
Harkirat Kaur
Janet Mansaray
Deannah Neupert
Wanderson Novais
Sofia Ocampo
Varsha Pathare
Adam Ramsey
Philippa Stone
Jessica Szetela
Nicole Vaccaro
Imeña Valdes
Gabriela Villani
Renate Wuersig

READ ABOUT PLANTINGSCIENCE DIGGING DEEPER RESEARCH RESULTS: FREE ARTICLE IN THE *AMERICAN BIOLOGY TEACHER*

An article on the efficacy of the PlantingScience Power of Sunlight program has been selected as the free article in the September issue of the *American Biology Teacher*: https://nabt.org/files/galleries/ABT_Online_Sept_2023.pdf

This article reports on the results of our 2015–2019 research studying the efficacy of the PlantingScience Power of Sunlight module. The research showed positive gains in participating students' content knowledge and attitudes about scientists over students who learned photosynthesis and cellular respiration the way their teachers normally taught those topics.

We're honored to be selected and hope that the article will have a wider reach since it is open access!

U.S. Department of the Interior
Bureau of Land Management

Plant Conservation & Restoration Program

Native plants are the true green infrastructure we rely on for healthy, resilient, biodiverse ecosystems. As wildfires and other climate-driven disasters continue to devastate the U.S., the BLM Plant Conservation & Restoration Program is implementing the National Seed Strategy and conserving and restoring the native plant communities that define America's iconic landscapes and provide wildlife habitat, ecosystem services, and recreational opportunities for all Americans to enjoy.

blm.gov/nativeplants
blm.gov/seedstrategy

STUDENT SECTION

Botany 2023 Review

It was so great seeing so many of your faces again in person at Botany 2023 in Boise! Students made up 53% of the total conference attendees with 494 total students. About a quarter of the students were undergraduates and three quarters were graduate students. About 85% of total students attended the conference in person. The popularity of face-to-face attendance at Boise highlighted how important it is to have in-person interactions to cultivate our botanical network. At the same time, about 15% of students attended virtually. We hope the opportunity to tune in remotely helped students stay connected to the botanical community this year, even though they couldn't be there in person.

The Student Reps worked to encourage more interactions between students and the botanical community at a variety of events. Our first event of the week was the *Writing Your CV and Translating it Into a Public Facing Website* on Sunday, where seven superstars in their respective areas of sci-comm shared tips for engaging audiences about plants. The next day, we held the widely popular *Careers in Botany Luncheon* where we had 12 panelists for students to connect with. We then helped host a very well–attended *Student Social* at the Linen Building where we chatted late into the night. We also held a virtual *Student Chapter Meetup* where we discussed ideas to connect members with other chapters across the country.


By Eli Hartung and Josh Felton
BSA Student Representatives

Reach us by email or X (formerly Twitter): Eli at elishartung@gmail.com / @hartung_eli or Josh at feltonjosh@icloud.com / @JoshFelton12.

CAREERS IN BOTANY LUNCHEON

At the Careers in Botany Luncheon, we had 12 panelists with careers in academia, government, non-governmental organizations, consulting companies, herbaria, botanical gardens, and museums. They represented the spectrum of career stages, and collectively, they work in five countries and ten U.S. states. A total of 106 students attended—one of our best attended luncheons yet! Below was the flier we used to advertise the event, and here is where you can read more about the panelists at the Careers in Botany Profiles: https://botany.org/home/careers-jobs/careers-in-botany/careers-in-botany-profiles-2023.html

STUDENT SOCIAL

Thank you to the 143 of you who attended the Student Social! We had a great time getting to know each other at the Linen Building in Boise. Hope to see you all again at the next student social in Grand Rapids, Michigan!

WRITING YOUR CV AND TRANSLATING IT INTO A PUBLIC FACING WEBSITE WORKSHOP

Our first CV writing/website building workshop was a great success with 7 panelists and 12 attendees. The workshop panelists were a diverse group of plant scientists with experience in both CV building and website management. First, the panelists spent a few minutes introducing themselves and their work. Then, panelists presented tips on CV building/formatting and provided feedback to students on their CVs. Finally, panelists showed their websites and provided advice as students built their own websites. We learned so much from the panelists, both through their engaging presentation content and style, and in the super interesting small discussions. Read the section "Heard at the Writing Your CV and Translating it Into a Public Facing Website Workshop" to learn some tips from our panelists.

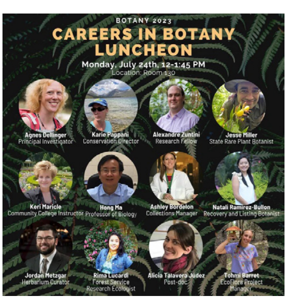
STUDENT CHAPTER MEET-UP

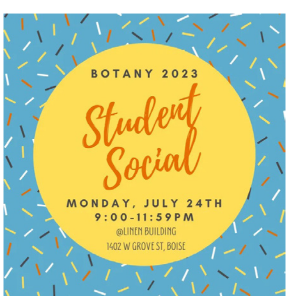
We held our first ever Virtual Student Chapter Meet-up at the conference this year. The event was initiated and organized by our very active student chapters. We would love to host this at the conference each year. To maintain this momentum, the Student Reps are planning more of these Student Chapter Meet-ups as part of the Botany360 program. Stay tuned on the @Botanical_ X (Twitter) and BSA Student Newsletter to hear more details.

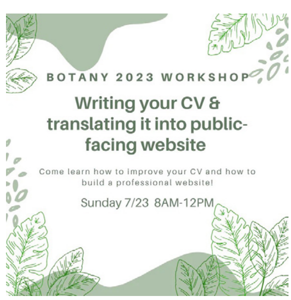
NETWORKING BOARD

For our conference Networking Board, we heard from 7 labs recruiting for more than 13 positions including Masters and PhD student, research assistant, post-doc, and technician openings in 7 states across the country. Be sure to reach out to them using the contact information listed on the board!

We also heard from 18 early-career researchers looking for graduate school positions, post-docs, jobs in industry, government, and lab or field positions. Those of you recruiting, please check out this list! https://tinyurl.com/networkingboard







ANNOUNCEMENTS

IN MEMORIAM

Photo provided by Allen Crawford.

JOEL FRY (1957-2023)

It is with great sadness that we note the passing of Joel Fry on the 21 March 2023. Joel was a world-renowned scholar centered at Bartram's Garden, America's oldest surviving botanic garden, founded in 1728 by John Bartram and still a working historical garden on the western bank of the Schuylkill River running through Philadelphia. Joel's work at Bartram's Garden encompassed archival history, archaeology, anthropology, horticulture, gardening, field botany, and so much more. Joel generously shared his wealth of knowledge with scholars, amateurs, and all who showed an interest in the world around us. He reached across disciplines and counted historians and gardeners and botanists among his numerous friends and colleagues.

As just one example of Joel's ability to work across disciplines, during digitization of specimens at the Herbarium of the Academy of Natural Sciences (PH), a specimen collected shortly after the Battle of Gettysburg was discovered. The specimen was collected by Thomas Meehan who, in addition to being a member of the Academy of Natural Sciences of Philadelphia (Botany Department) and a prominent nurseryman in Philadelphia, had worked at Bartram's Garden early in his career, shortly after he arrived in the U.S. from England. This connection led to a scholarly partnership that Joel dove into, providing numerous and eloquently written inputs, which led to a publication in 2022 (McCourt et al., 2022).

Joel got his MS in Historical Archeology from the University of Pennsylvania and began working at Bartram's Garden in 1992. He worked there for more than 30 years until his death at age 66. Joel always welcomed visitors to Bartram's Garden, including neighbors and people visiting from near and far, including numerous visitors from all over the world; students from local colleges and universities; and members of local natural history organizations like the Philadelphia Botanical Club and the Delaware Valley Ornithological Club.

The first field trip of the Philadelphia Botanical Club was to Bartram's Garden, in 1892, and in 2012, to celebrate the 120th anniversary of that event, Joel led a botanical excursion at Bartram's. Only three species were listed from that 1890s field trip report (*Eranthis*

Joel Fry showing off the newly acquired Bartram desk in the Historic Bartram House in Summer 2022. Photo provided by Bartram's Garden.

hyemalis [winter aconite], *Ptelea trifoliata*, and *Aralia spinosa*). Joel assiduously researched where those species might and might not be at Bartram's, and only one, *E. hyemalis*, is still found at Bartram's Garden (https://growinghistory.wordpress.com/2012/02/24/a-visit-to-bartrams-garden-with-the-philadelphia-botanical-club/). This is an example of the diligence and thoughtfulness that Joel put into all his work. Joel's scholarly publications are nonpareil, and his work outside of academic publishing equaled the excellence of his more formal scholarly work. However, the thought of calling anything having to do with Joel "formal" would seem outlandish to all of us who knew him—Joel's lack of formality undergirded everything he did. If he could learn something and share it with the world, he did all he could to do that work with excellence.

Joel traced the movement of plants across the Atlantic (Fry, 1996) and throughout North America (Fry, 2000). Joel's rigorous research on the archival history and the botany of plant movement leads to knowledge that critically informs the biology of the movement of plants, in cultivation, as well as naturalization, and increases our understanding of how extinction in the wild interacts with horticulture and conservation in gardens.

Joel contributed freely to a range of scholars, as a glance through the acknowledgments of numerous papers clearly shows (e.g., Schoonderwoerd and Friedman, 2016; Gladfelter et al., 2020). Acknowledgment of Joel's contributions in many books also shows his generosity of spirit (for example, Andrea Wulf's *Founding Gardeners*; and Victoria Johnson's *American Eden*).

One of Joel's unfinished projects was a study of southern New Jersey plants the Bartrams knew. This began with his and Bill Cahill's realization that the Sutro Herbarium at the Huntington Library contained specimens John Bartram must have collected in "Jersey," because this *hortus siccus* predated his trips further south than Delaware (then part of Pennsylvania) and Maryland. They recognized, for example, the *Diapensia* species *Pyxidanthera barbulata* from a shriveled, disintegrating specimen, and the pine barren gentian *Gentiana autumnalis,* which Bartram couldn't have found closer to home. With this they began to look further, eventually listing a few hundred plants from the Sloane Herbarium in London (once it became available in digital online images) and other sources that gave a detailed understanding of the Bartrams' local botanical knowledge. John and William Bartram were famous botanical travelers, but the evidence of this study showed that they learned much of their botany locally, even as a preparatory study for understanding plants in the far-off regions they visited. Fry and Cahill also traced reiterations of this botanic interest in the flora of Philadelphia and southern New Jersey in the work of William P.C. Barton (1818), Nathaniel Lord Britton (1880), and Ida Keller and Stewardson Brown (1904). They also found Bartram provenances for taxa named by others, such as the pine barren shrub *Leiophyllum buxifolium* Bergius, which was communicated to Bergius by a Swedish correspondent who knew the Bartrams in Philadelphia.

On the 7th of September 2023, a gathering was held at Bartram's Garden in Philadelphia in remembrance of Joel, in a place that not only was a center for him, but in many ways, one might say, was centered on him. Many gathered and remembered his knowledge (phenomenal), his erudition (brilliant), his sense of humor (high spirited), his generosity (endless), and most of all, his friendship, which will be dearly missed.

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--By David Hewitt, Richard McCourt, and William Cahill

DR. JOHN KISS FEATURED ON THE SPACE SHOW

BSA Member John Kiss was recently featured on an episode of the radio show *The Space Show*. Topics included gravitational and space plant biology for the Moon, Mars, free space, Cislunar space, and more. Kiss also talked about plant needs, challenges, human components, radiation, the role of microgravity, and the quality of light plus water needed for space biology.

The episode can be found at: https://www.thespaceshow.com/show/18-aug-2023/broadcast-4075-dr.-john-z.-kiss.

THE SPACE SHOW®
HOST DR. DAVID M. LIVINGSTON

BOOK REVIEWS

A Generic Classification of the Thelypteridaceae
Flora of Colorado, Ed. 2
Getting In: The Essential Guide to Finding a STEMM Undergrad Research Experience. 2nd Edition
Jackfruit: Botany, Production and Uses
Mistletoes of the Continental United States and Canada
Moving Crops and the Scales of History
Orchid
Planting Clues: How Plants Solve Crimes
Putting Down Roots: Foundations of Botany at Carolina with a Concluding Chapter on the History of the Department of Botany
Stelar Evolution and Morphology In Selected Taxa Based On The Study Of Vascullotaxy (Studio Nov.), Ed 2
Taylor's Seedling Drawings: A Catalog of Cotyledons

A Generic Classification of the Thelypteridaceae

Susan Fawcett and Alan R. Smith
2021. ISBN 13: 978-1-889878-68-3
Flexbinding, US$25.00; 112 pp.
BRIT Press

Although presented as a book, this work is more like a long journal paper covering the classification of the Thelypteridaceae. It is laid out just like any other such paper with an introduction, illustrations, keys, etc. The classification of the fern genera reflects phylogenetic work done by the authors that was also published in 2021.

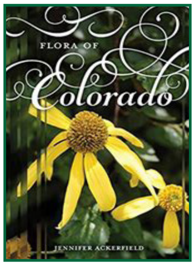
Many gardeners bemoan the name changes that angiosperms have undergone in the last few decades, but if only they knew what has happened with fern classification! The advent of next-gen sequencing has given us a much deeper insight into the evolutionary history of these fascinating plants; therefore, many new names have been created and old ones reinstated. Fawcett and Smith's work here clarifies this particularly complicated family and provides a new classification that was sorely needed. The authors publish 176 new names and recognizes 37 genera. The authors do a good job reviewing the taxonomic history of the family and the botanists that came before them who tried to make sense of these plants. A number of line drawings and photos are included to illustrate the ferns. The bulk of the paper consists of the taxonomic descriptions of each genus, which also include the history of each one's circumscription, geography, and references.

The wealth of information in this work is wonderful and it is apparent that the authors truly enjoy working with these plants. Anyone looking to know more about the family or put updated and correct names to their Thelypteridaceae specimens should purchase this.

-John G. Zaborsky, Botany Department, University of Wisconsin – Madison, Madison, Wisconsin, USA; jzaborsky@wisc.edu

Flora of Colorado, (ed. 2)

Jennifer Ackerfield
2022. ISBN 978-1889878898
US$80; 872 pp.
BRIT Press



Colorado's flora is rich due to the diversity of habitats, from the Eastern Plains to the Rocky Mountains and the high deserts of the Western Slope. To help botanists identify the plant species, there have been numerous floristic works, from the checklist of Porter and Coulter's "Synopsis of the Flora of Colorado" (1874) to the seminal "Manual of the Plants of Colorado" (1964) by Harold Harrington. More recently, William Weber and Ronald Wittmann divided the state at the Continental Divide and published separate floras for the Eastern and Western Slopes, with the fourth editions published in 2012. These floras contained keys but lacked species descriptions and distribution maps, and often used unconventional nomenclature. For many users, this last feature made Weber and Wittmann's floras difficult to use. As a resident of western Colorado, I appreciated a flora that focused on plants of my region while excluding those of the eastern plains. However, a modern flora covering the entire state was lacking.

In 2015, Jennifer Ackerfield published the first edition of the *Flora of Colorado*. This up-to-date flora used conventional nomenclature, taxonomic changes ushered in by the molecular age, succinct species descriptions, distribution maps, and 912 images covering nearly one third of the plant species in the state. I appreciated the county map on inside of the front cover and the ruler on the inside of the back cover, an indispensable feature for field identification. To say the first edition was well-received by Colorado botanists is an understatement! It quickly became the go-to flora for Colorado botanists.

The second edition of the *Flora of Colorado* includes many updates. Nomenclatural changes have been included as have new taxa that have been recognized, collected, or identified since the first edition. The first edition contained 3322 taxa (including 645 varieties and subspecies) whereas the second edition contains 3352 taxa. Among the new taxa are two species of *Cirsium* described by Ackerfield in 2022.

The second edition is beautiful, with a cover photo of a misty mountain meadow with *Veratrum* and *Delphinium*. The cover of the second edition seems to be made of thicker, tough paper then the first edition. This is a welcome addition, given how torn and tattered my well-used first edition has become. The second edition is a full centimeter thinner than my first edition due to the slightly wider pages. It is still a rather large volume to take into the field, but the ability to key out any plant in Colorado is well worth the extra weight in a backpack.

New distribution maps are one of the major and most eye-catching updates. The first edition included county-level distribution maps. These provided a rapid overview of distribution, but the new dot-distribution maps give more detail as to exactly where collections have been made as well as a general idea of how frequently specimens are collected. These improvements are due to large-scale databasing efforts and availability of specimens online. It took a little time for me to get used to the dot-distribution maps and the dots are small, making them a bit difficult to see; however, I appreciate the added precision. The discussion of the maps as well as the heat map of herbarium collections (p. 14) are quite interesting, and I appreciate that Ackerfield takes the time to discuss their creation, what data were included, and what data were excluded.

The images in the second edition are greatly improved. There are 1296 color images on 108 plates (versus 912 images in the first volume). Not only is the quantity improved, but these images are more informative. I particularly appreciated the inclusion of multiple photos, such as in the Cyperaceae and Poaceae plates, covering both fine-scale characters like the flowers as well as overall appearance of the inflorescences. Additionally, Ackerfield has included black-and-white images within the keys for particularly difficult taxa. The images of Amaranthaceae bracts and fruits (pp. 78-79), Boraginaceae nutlets (pp. 230-231), and Nyctaginaceae anthocarps (pp. 575-578) are all helpful when looking at difficult but diagnostic characteristics.

The keys in the first edition were easy to use, generally included many characters, and worked well. My initial impression is that the keys have not changed significantly, although with more use differences may come to light. Given how thorough and well done the first edition was, it is not surprising that there are not significant differences.

Compiling a flora will always come with compromises. This is a technical key, so those wanting a plant identifier picture book should look elsewhere. One criticism of the *Flora of Colorado* is that the species descriptions are not complete. In my opinion, between the description of the genus, the key highlighting the difference between taxa, and the succinct descriptions, the *Flora of Colorado* does an excellent job giving a description of taxa without redundant, unnecessary verbiage. Shorter descriptions are also necessary to keep the length and weight of the book down so that it can be taken into the field.

While I will keep hold of my torn and tattered first edition, I am thrilled to have a new, updated edition of the *Flora of Colorado*. The first edition of the *Flora of Colorado* was a huge leap forward for Colorado botanists and the second edition finetunes this work. The value of this work cannot be underestimated. I experienced this firsthand during my Plant Identification course in the Fall of 2022 when the first edition was out of stock and the second edition had yet to be released. I did not fully appreciate the value of this flora until it was unavailable! Botanists in the state are lucky to have such a thorough yet concise flora.

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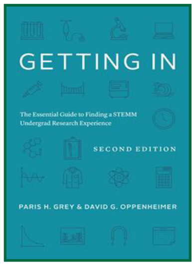
--Stephen Stern, Ph.D., Professor of Biology, Department of Biological Sciences, Colorado Mesa University, Grand Junction, CO 81501; Email: sstern@coloradomesa.edu

Getting In: The Essential Guide to Finding a STEMM Undergrad Research Experience. (ed 2)



Paris H. Grey and David G. Oppenheimer
2023. ISBN-10: 0226825418; ISBN-13: 978-0226825410
US$20.00 (soft cover); 253 pp.
University of Chicago Press

Undergraduate research is a high-impact practice that can transform the lives of students and lead to increased retention of students (Weber and Myrick, 2018; Lanning and Brown, 2019). This type of experience certainly made a big impact on my life and is the reason I am an academic today. As an undergraduate, I did two different independent research projects—one in field ecology and another in electron microscopy—and then decided that graduate school and academia was for me. Of course, undergraduate research in STEM fields can be for almost all students and can become a valuable part of their training.

As a faculty member, I have come full circle and continue to enjoy mentoring undergraduates in independent research. Some of these students go to graduate school and others to medical school. In the latter case, I always think that it is good for physicians to understand the nature of scientific research. My best students have been co-authors on papers. One of my undergraduates (who is now a tenured faculty member) discovered a novel photosensory mechanism in plants (Ruppel et al., 2001), which served as the basis for a successful grant proposal for a spaceflight project with NASA (Millar et al., 2010; Kiss et al., 2012)!

This book provides a fantastic and comprehensive overview of all aspects of undergraduate research in STEM fields. Part 1 (Chapters 1–3) covers the basics such as the benefits of research as an undergraduate, a primer on types of STEM research, and an overview of lab culture. Part 2 (Chapters 4–6) considers detailed strategies of applying for research positions as an undergraduate.

There are many reasons to pursue undergraduate research, and a few are outlined above. However, Chapter 1 provides a very thorough list of the benefits—both obvious and less-than-obvious ones. For instance, it is well known that undergraduate research will help get a student into graduate school. Other benefits and skills include: upholding a commitment, working well with others, embracing constructive feedback, developing organizational strategies, developing outstanding communication skills, strengthening self-discipline, learning time-management skills, improving critical thinking, among others. The authors speak of these benefits with conviction and passion. Chapter 2 is an introduction to research groups and lab culture in STEM and serves as a good overview of the research process. The authors consider lab work, field research, clinical studies, and other types of research.

The authors also posit in Chapter 3 that undergraduate research is great for all types of students (Laursen et al., 2010)—not only honors or high-GPA students—and I completely agree. To make this point, the authors write, "Most scientists aren't geniuses or even brilliant. What they are is interested in their research and resilient when managing disappointment and failure." This last statement is one of the most accurate ones that I have read about scientists and gives insight into the nature of science. The answer to the question of when a student should start a research project is given by the comment that you should start your research experience as soon as you can handle the time commitment. The advantage of starting sooner is that the longer you are in the lab, the more likely that you will have a meaningful research experience (e.g., attend scientific meetings, perhaps co-author a paper).

The next several chapters (Part 2 of the book) cover all aspects of applying for research positions. One consideration is whether the student wants to do work at their own college or university or apply to one of the many Summer Undergraduate Research Programs (SURPs). This book is very comprehensive in all aspects, and the authors consider items such as application strategies and how to interview with a Principal Investigator.

The authors are both experienced science faculty who have mentored many students in their labs. They also actively promote undergraduate research via social media such as Instagram and X (formerly Twitter): @YouInTheLab. This book is great for many groups such as undergraduates thinking about research or those already engaged in such work as well as their faculty mentors. It can be used as part of a course that meets to provide mentoring for undergraduate researchers and is an inexpensive, enjoyable, and a fun read as well.

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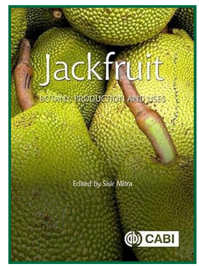
Jackfruit: Botany, Production and Uses



Sisir Mitra, Editor
2023. ISBN: 978-1800622296
US$170 (Hardcover); 292 pp.
CABI Publishing, Oxfordshire, U.K.

Jackfruit: Botany, Production and Uses comprises 13 chapters dedicated to exploring the life and times of jackfruit, the fruit-bearing evergreen tree. It begins with a botanical introduction of the Moraceae family, of which jackfruit (*Artocarpus heterophyllus*), figs, and breadfruit are members. Mitra's Preface provides readers with a brief account of jackfruit's origins, noting that it is native to the Western Ghats mountain range, which runs north–south along the western coast of India. Because of the tropical climate of the lowlands in South and Southeast Asia, where jackfruit is cultivated, it enjoys a long growing season. Jackfruit has several purposes, providing major jackfruit-growing countries such as Bangladesh, the Philippines, and Vietnam with food, fuel, timber, and medicinal and industrial products (p. xi). Jackfruit is also grown in Belize, Jamaica, and Florida. And although jackfruit is a major staple in South and Southeast Asia, it is an understudied plant, taking a backseat to the avocado, mango, and coconut tree.

Most things a horticulturalist, botanist, farmer, and crop scientist may want to know about jackfruit cultivation, including breeding and propagating methods, can be found in *Jackfruit*. There are directions for propagating jackfruit with cuttings or by grafting. There is information about soil nutrition, fertilization, and irrigation practices for increasing the quality of the tree and its fruit. Orchard managers will find the "Orchard Management" section instructive as it provides a roadmap for starting and maintaining a jackfruit plantation, replete with information about pruning and training and intercropping. Importantly, while jackfruit is easy to grow and maintain, the "Biotechnology" chapter stresses the importance of using such tools as plant tissue culture, genetic engineering, and marker-assisted selection to improve crop production.

The very climate in which jackfruit thrives also invites such pesky pests as the jackfruit borer, which burrows into the fruit and shoot of the tree, and the red-spotted longhorn beetle, which can wreak havoc on jackfruit's stem and trunk system. Fruit flies and bark-eating caterpillars, which also feast on the fruit and bark of the tree, are also a nuisance for the jackfruit. Plant physiologists, forest entomologists, and forest pathologists whose research focus is on the pests, diseases, and physiological disorders afflicting the evergreen will find these chapters valuable. Each provides specific details on the lifecycle of the pests and diseases; the specific trajectory they follow in young and mature jackfruit tree; their effects on the whole tree, from crown to root; and what pest and disease control techniques can be employed to ensure strong growing conditions that produce high-quality jackfruit trees.

Although jackfruit trees are not free from pests and disease, they are termite resistant, which is why the tree's beautiful golden-colored wood is used to build furniture, houses, and boats. In India, the timber is used to build the veena, a string instrument resembling a sitar (Chandrashekhar et al., 2021). Jackfruit also grows naturally in backyards and is used as a windbreaker, lining major avenues in countries such as Bangladesh and Sri Lanka. In addition to being drought resistant (jackfruit can tolerate about 3 to 4 months of dry period, *and* it can tolerate a bit of frost), it can withstand strong winds and has been shown to survive hurricanes, recovering well from losing leaves and branches (Elevitch and Manner, 2006, pp. 6–7).

Those herbalists and ethnopharmacologists interested in the medicinal and pharmacological attributes of jackfruit will find Bhattacherjee's "Composition and Uses" chapter a useful introduction. As a nutraceutical, jackfruit has many medicinal, nutritional, and health-giving benefits, and Bhattacherjee notes that the bioactive compounds flavonoid and phenolics in jackfruit serve as powerful antioxidants, anti-inflammatory, and anti-cancer agents and have been used to successfully treat cancers of the skin, lung, and breast (p. 40). He also notes that jackfruit is "one of the rare fruit sources of B Vitamins" (p. 40).

One of the best features of *Jackfruit* is the "Processing and Products" chapter, which explores how the whole tree is processed and what kind of food and industrial products it yields. When it is green and unripe, jackfruit can be cooked and eaten as a vegetable, and when it is ripe, jackfruit is eaten as a fruit.

Its seeds can also be boiled and sauteed or roasted. One can enjoy jackfruit candy, jackfruit chips, and jackfruit ice cream. Chefs who are interested in cooking the rice dish biriyani, for instance, will find step-by-step instructions. The tree is so versatile that it is even used as a meat substitute; its fibrous texture resembles meats like chicken or pork (Ghangale et al., 2022).

Overall, *Jackfruit: Botany, Production and Uses* is an excellent compendium of this hardy multipurpose perennial tree. Crop scientists, horticulturalists, farmers, botanists, plant physiologists, and cooks will find *Jackfruit* an accessible starting point for precursory research. As climate change gives rise to prolonged periods of droughts and severe flooding, jackfruit will be a formidable crop because it can resist drought and thrive with little maintenance. The jack of all fruit-bearing evergreen trees, jackfruit will soon be coming to a grocery store near you.

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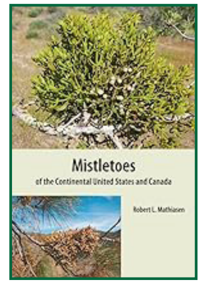
Mistletoes of the Continental United States and Canada



Robert L. Mathiasen
2021
ISBN 13: 978-1-889878-66-9
Flexbinding, US$25.00; 220 pp.
BRIT Press

Mistletoes are a fascinating group of parasitic plants that have a long history of use by humans. This book covers the ecology, classification, and biology of the genera *Arceuthobium*, *Phoradendron*, and *Viscum* in North America north of Mexico.

Firstly, this is one of the best monographs I have seen in a long time. The author is an expert in the group, and he clearly cares about these plants. The book is filled with color range maps, line drawings, classical illustrations, comic drawings, and many color photos. The book has detailed information about the biology of mistletoes, how they infect their hosts, interactions with animals, cultural significance, as well as taxonomic keys to the species.

Each taxon covered has such information as its description, hosts, geographic range, general notes, and references. The author exhaustively lists each mistletoe's hosts and how frequently they have been found on each one. Oftentimes the host is important to correctly identifying the mistletoe, as is geographic range. There are wonderful photos throughout of the mistletoes and their hosts. The author even gives locations to easily view some of the species if a reader is so interested! After the taxonomic information, there are numerous sections on how animals interact with mistletoes as dispersers and pollinators, among others. Mistletoes have deep cultural significance with humans as pests of timber trees, as medicine, and, perhaps most famously, as a part of Christmas traditions. All of these aspects are covered in the book.

This is truly a wonderful and well-done work that is the go-to reference for information on these plants. It should also be used as a guide to anyone looking to write a monograph on any plant.

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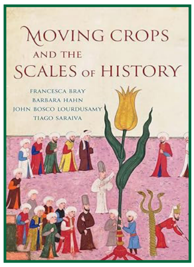
Moving Crops and the Scales of History



By Francesca Bray, Barbara Hahn, John Bosco Lourdusamy, and Tiago Saraiva
2023. ISBN 978-0-300-25725-0
US$40.00 (cloth); 338 pp.
Yale University Press, New Haven, CT

My understanding of the relationship between man and his crops was first influenced by Edgar Anderson's *Plants, Man and Life* (1952) where he described some of the ways plants have been changed by man since the advent of agriculture. More recently, Michael Pollan (2001) shifted focus by providing "*A Plant's-Eye View of the World*." The authors offer a new paradigm—the "Cropscape" to study the history of crops from the interaction of six perspectives: time, place, size, actants, compositions, and reproductions, with a chapter devoted to each. Nearly two dozen crop plants supply the case study examples illustrating one or more of these perspectives while providing new insights to familiar stories.

The date palm provides a good example of different scales of time. Dates are one of the earliest tree fruits domesticated (more than 6000 years ago in Mesopotamia). With the domestication of camels a thousand years later, dates began to spread across Eurasia and North Africa at the center of oases, where the palm became the keystone species. After reaching Morocco around 400 C.E., trade moved south across the Sahara and, between 800 and 1500 C.E., sub-Saharan gold was moved to the Mediterranean. It was gold dust brought by camel caravan in 1441, not spices, that enticed Prince Henry of Portugal to sail around West Africa to the Gold Coast. In 1482 Portugal established the Elmina Factory (first slave factory) on the Gold Coast. But by then Arab influence in Spain was already in decline and the date palm's significance was as well—until it was introduced to California in the 1880s. Commercial production began in 1905 and Coachella, CA, became the center of U.S. production. However, the inability to mechanize and automate date growing, to this day, has limited the size of the industry, which remains dependent on migrant labor.

The significance of place explains the dust jacket image of "*Tulip Courtiers Procession, Istanbul*, 1533." Tulips, native to central Asia, were being grown in Asia Minor 3000 years ago. By 1500, the Ottomans had bred the almond-shaped form, with long pointed petals, which were highly desired in Istanbul; tulip cultivation was a profitable business, drawing buyers from Europe and Asia. In 1560 the Hapsburg ambassador to Istanbul brought some Turkish tulip bulbs back to Vienna, and eventually some were sent to Clusius in Leiden where he began breeding a striped form. The Dutch favored the showy striped petals, and business (and speculation) took off, until it crashed in the infamous tulipomania economic bubble burst of 1637. Sixty years later, a new Sultan, Ahmed III, promoted modernization and westernization of the Ottoman empire and brought in waves of Dutch tulips to beautify Istanbul and especially the new palace garden—the so-called "Tulip Period." A violent popular uprising against the extravagant expenditures on European frivolity brought an end to his reign in 1730. The Islamic reactionism against Europeanized tulips set the Ottomans against European modernism through the beginning of the 20th century.

The orthodoxy of "bigger is better" and "smaller is beautiful" typifies the roles of size in agriculture, but coffee, and especially tobacco, illustrate how size desirability changes in different cropscapes. Coffee was originally grown in small plots, but the economics of large-scale slave plantations in Java and Brazil shifted the cropscape. Today, we again see a shift favoring smaller production of organically grown varietals. Similarly, original tobacco production was as a cash crop in small family plots, but ultimately labor availability promoted plantation-scale production. In the U.S., during reconstruction, plantations were divided into small share-cropper plots, but processing still required hand labor. Beginning in the 1970s, automation in growing, and especially processing, again threw the balance toward large-scale production.

The traditional actants are people, but since Pollan we've begun to consider the plants themselves as actants. Cropscapes provide additional considerations. It is easy to include pathogen interactions with the plants that interact with people, but Cinchona is among the examples that allows the authors to take it farther—the plant consists of three different actants. On the one hand, "Jesuit bark" was an actant as materia medica providing a malarial cure that supported European colonialism. Alternatively, the Cinchona tree could be propagated in gardens around the world, facilitating the tree's spread and availability. The active principle, quinine, became a chemical actant once it was isolated. In nature these three actants work in concert, but under human influence each can exert separate influence in the cropscape.

Compositions are a cropscape to which biologists apply a different name: ecologies. Even the most homogenous crop field is a patchy cropscape when viewed close-up. Included are a variety of competing actants, such as weeds, pathogens, and symbionts. But on an even larger scale, for every crop grown for profit with slave labor or share-cropping, there are one or more other crops grown primarily to feed human laborers. Finally, any "waste" produced can be composted to become another actant reclaiming the soil.

In the final chapter on Reproduction, the authors highlight the negative impact of modern agricultural practice on crop diversity. The highest biodiversity occurred during early domestication as land races were selected in the sites of domestication. By the 1850s pedigree selection and the founding of seed companies (what Mendel had to work with) already began to limit available biodiversity. In the early 20th century, even as scientists like Vavilov began collecting seed stock of land races and wild relatives of crops, governments began to limit what could be grown. For instance, the German Seed Law (1934) allowed only 16 of 454 wheat varieties and 74 of 1500 potato varieties to be planted by German farmers. The authors highlight the importance of modern seed banks such as the Svalbard Global Seed Vault and the push by the U.N. Food and Agriculture Organization (FAO) and others to move food production to a smaller scale to preserve our global agricultural heritage.

This is a small book, but it is scholarly and packed with information to support the authors' novel concept of cropscape. For these reasons it is not an easy, light read. Numerous endnotes are provided for each chapter, and an extensive bibliography facilitates further investigation. You will recognize each of the crops used as a case study, but you will likely learn something new about each one. Anyone teaching economic botany will find this a useful resource. For college students, it's the kind of book that illustrates the value of interdisciplinary collaboration and justifies general education requirements. In each chapter, both science and the liberal arts are integrated in the formulation and evaluation of every example presented. This would be a good book for an upper division/graduate reading seminar; I would have used it in my introductory Honors biology course for majors and non-majors.

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Orchid

Dan Torre
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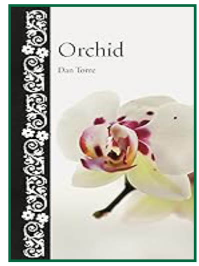

Books about orchids may deal with a group, a genus or the entire family, cultivation, taxonomy, and/or, in a few cases, science. This book deals with all of these and several topics that are seldom if ever found in orchid books. Selection of topics and coverage seem to reflect the author's interests. Or, maybe the book tries to justify the quote from Sir David Attenborough above the introduction, which states that orchids "are surely the most glamorous of plants," despite the fact that some species lack glamour.

The introduction tells us that orchids may look "like monkey faces [*Dracula simia*] . . . flying ducks [*Caleana major*] . . . even our own anatomy" without identifying the anatomical parts. Maybe the author had in mind flowers of *Orchid italica,* which look like humans (or at least humanoid). There are also suggestions that parts of some *Cymbidium, Dendrobium, Phalaenopsis,* and *Vanilla* flowers are more (human) sexually explicit, but I do not think so. Maybe the flowers of several *Calochilus* and *Telipogon* species are better examples, or at least deserve a second look.

Chapter 1 deals with the understanding of orchids and does a good job of it, despite its brevity, when one considers the size of the Orchidaceae and its numerous structural, anatomical, and physiological adaptations and variations. An assertion in the book that orchids may have originated 100 million years ago may generate disbelief, but there is good evidence that this is the case. They may even go back 120 million years. Insects bearing orchid pollinia encased in amber suggest that orchids coexisted with dinosaurs. My question is whether dinosaurs ate orchids, enjoyed their beauty, wore corsages, or ignored them.

The author, an Australian, thinks that orchids originated in Australia. Since the millions of years old amber-encased pollinia were discovered in the Dominican Republic, which is not even close to Australia, I wonder. The author suggests Gondwana. Another suggestion is Pangea. There is no certainty. Whichever it was, orchids migrated far and wide. My complaint about this chapter is that it is teleological and anthropomorphic in places. Orchids don't "use clearly deceptive" and "wait until their flower." They "evolved clearly deceptive" and "develop ovules after…."

"Understanding Orchids" was an appropriate title for the first chapter; however, "The Secret Life of Orchids," the name of the second chapter, which deals with pollination, may be intended to create anticipation or be designed to usher the reader into a non-existent mystery, does not belong into a serious book. Orchids have evolved many elaborate, complex, and wondrous pollination mechanisms, but there is nothing secret about them. The author describes them well and clearly.

The aptly named third chapter, "Discovering Orchids," deals with how humans got to know and use orchids. The author's homeland again comes to the fore because he suggests that Aboriginal Australians may have started to eat orchids 60,000 years ago. There is no mention of other humans who may have done the same approximately that early or earlier. For example, humans settled the Maluku archipelago at least 40,000 years ago. Ambonese consumed pickled orchid leaves (but I could not find any on my visit to Ambon). The chapter also deals with orchid mania (which started in the mid-1700s), orchid hunters, and the commercialization with orchids as plants and cut flowers.

A section called Early Scientific Discoveries is also part of Chapter 3. It should have been included in Chapter 2 because it deals mostly with pollination including pseudocopulation (for reviews, see Pouyanne, 1917; Kullenberg 1950, 1961; Kullenberg and Stenhagen, 1963-1973). There is also a misleading statement in the third chapter. "One of the first successful orchid hybrids [that] occurred" was not a *Cattleya* in 1853. It was *Calanthe* Dominii (*Calanthe masuca* × *Calanthe furcata*; these species have since been renamed at least once and are now *Calanthe sylvatica* and *Calanthe triplicata*). The cross was made in 1853, seeds were obtained in 1854, a seedling flowered for the first time in October 1856 (its novelty and appearance caused John Lindley, who named it, to exclaim, "You will drive the botanists mad"), and the hybrid was registered in 1858. *Cattleya* Hybrida (*Cattleya guttata* × *Cattleya loddigesii*) was registered in 1859 (orchid hybrid parentage and dates can be found at https://apps.rhs.org.uk/horticulturaldatabase/orchidregister/orchidregister.asp; also see Anonymous, 1858; Arditti, 1984a).

"Picturing Orchids" is the fourth chapter. It deals with orchid representation in sculptures, drawings, art, and designs starting with an early Roman frieze in the Augustus era in 9 B.C. and ending with very recent paintings. Coverage of paintings is detailed, interesting, and informative, but limited (for more extensive treatment of orchids in art, see Quinn, 2009). Two general problems with orchid illustrations in this chapter and the entire book are:

- Uneven quality, which may be due to printing of the originals. Most are clear and pleasing; a few are marginal (pp. 94, 118).
- Selection: Paintings taken from the great British illustrated books of the 1800s are excellent (e.g., *Epidendrum macrochilum* from Bateman's *The Orchidaceae of Mexico and Guatemala* on p. 73). Those from the French language *Lindenia* are of much lower artistic and botanical quality (e.g., *Dracula simia* on p. 100). This painting is supposed to show flowers that look like monkey faces, but none are really visible, not even after reading the text, which indicates that they are. Both the *Lindenia* and the British books are now in the public domain. It would have been just as easy and inexpensive to take paintings from the British works, which are always excellent, as from the invariably much lower quality ones from *Lindenia*.

Chapter Five, "Pop Culture Orchids," is fun and a pleasure to read. The chapter deals with orchids that exist only in fiction and are killers, thieves, adventurous superheroes, involved in crime, and appear in comic strips. Unfortunately, the selection of examples is not extensive enough (for broader, but now probably outdated reviews, see Arditti, 1979, 1980, 1984b; Hoffman Lewis, 1990). I will dwell on two examples.

In 1894, H. G. Wells (1866-1946), of *War of the Worlds* and *Time Machine* fame, wrote a story called *The Flowering of the Strange Orchid*. In it, the orchid sucks the blood of its owner Winter Wedderburn, who generally lives a dull life. I will not say too much about the plot of this story or those that follow in order to encourage reading them. Two variations on this story were written. The first, *Green Thoughts*, published in 1932 by John Collier (1901-1980), is discussed on pp. 143-146. The second and best variation is by Arthur C. Clarke (1917 UK-2008 Sri Lanka), the famed British science fiction writer. It is not dealt with in this book, which is a pity. The story was published in 1956 in a collection of stories called *Tales from the White Hart*. Clarke gave me a copy in 1978 when I visited him in Colombo with the inscription, "For Joe Arditti, - Some hints on orchid keeping… Best wishes Arthur Clarke." In this story, the very timid Hercules Keating acquires a carnivorous orchid, which he decides to use to kill his overbearing aunt.

Unfortunately, what in my view is the very best science fiction story involving orchids, *Planting Time* by Pete Adams and Charles Nightingale, is not mentioned in the book. It is included in an anthology of science fiction stories called *Antigrav* edited by Philip Strick, published in 1975. This story is based on pseudocopulation of *Ophrys*. It involves a lonely space traveler, a planet in which orchids look like human (or humanoid) females, imaginative orchid breeding, and a chain of greenhouses on earth. It is well worth reading.

Consumption of orchids and their fragrances and medicinal used by humans are discussed effectively in Chapter Six. The same is true for conservation in Chapter Seven. A timeline of orchid events (206 BC-206) is on pp. 225-229.

References are presented in a hard-to-use, archaic format on pp. 231-241. Presenting the references in the standard format used in botanical literature would have been much better. A very short Further Reading list is on

p. 243. It does not include a number of major works (e.g., the late Robert Dressler's excellent book on orchid phylogeny) but does list a book or two I would not miss if they were unmentioned. A short list of Associations and Websites is on pp. 245-246. Various acknowledgments and an index conclude the book

This is one of the more unusual books on orchids I have come across. It covers many aspects of orchids, enough to make them interesting and instructive, but not sufficient for anyone to learn very much about most of the topics being discussed. Still, one can learn a reasonable amount.

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Planting Clues: How Plants Solve Crimes

By David J. Gibson
2022. ISBN: 9780198868606
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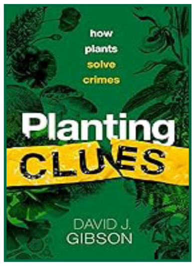


Planting Clues is a fascinating read for anyone interested in forensic botany. It is accessible to a general audience without being tedious for those with a deeper knowledge of plant biology. The book is structured so that each chapter covers a specific type of botanical evidence. Within each chapter, Gibson weaves descriptions of the relevant biological and forensic principles together with examples of cases in which each type of evidence played an important role in identifying, prosecuting, or exonerating a suspect. Many of the examples Gibson discusses are from the U.S., but cases from elsewhere, including the UK, Canada, and Australia are also included.

In the first chapter, Gibson focuses on the use of wood anatomy and tree growth in forensics. This chapter includes a section on the kidnapping of Charles Lindbergh Jr. in 1932, which is one of the earliest uses of forensic botany. As Gibson describes how anatomical features and manufacturing marks on the wooden ladder used by the kidnappers played a key role in solving the case, he introduces concepts such as growth rings, tracheids, vessels, rays, and softwood.

In Chapter 2, Gibson discusses the development and use of Locard's exchange principle that every contact results in an exchange of material. This chapter includes a brief history of forensic science, as well as discussions of the legal standards for introducing forensic evidence, the setting of precedent, and the use of expert witnesses—all of which are illustrated with examples that center on botany. This chapter gave me an appreciation of the processes involved in using botanical evidence in a courtroom.

Chapter 3 examines the forensic value of macroscopic plant parts that have been transferred to suspects and/or victims, including the identification of plant fragments in stomach contents. This chapter includes information about the nature of plant cells and structures such as seeds. Chapter 4, in turn, describes the forensic use of microscopic structures, including pollen, spores, fungi, and diatoms. Again, Gibson explores the history of how these areas of forensics developed and introduces basic botanical concepts such as pollen structure and dispersal and the life history of fungus. Not all examples are from violent crimes. For example, Gibson discusses the use of pollen and macrofossils to support land claims based on the oral histories of Indigenous Peoples in British Columbia.

Gibson turns to DNA in Chapter 5, beginning with a short overview of the history of using human DNA in forensics. He then describes cases that were solved, in part, using plant DNA. Interspersed throughout the chapter are descriptions of methodology such as PCR, DNA barcoding, and next-generation sequencing. This chapter also explores using plant DNA for verifying food items or supplements, and much of the chapter focuses on cases that have used DNA in an agricultural context for detecting genetically modified plants or genes, filed both by or against biotech companies.

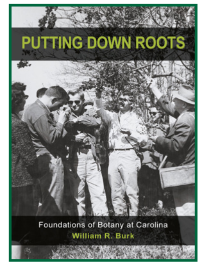
In Chapters 6 and 7, Gibson shifts away from the use of plants in solving cases and instead discusses the use of plants in committing crimes. Chapter 6 focuses on plant and fungal toxins and methods of forensic toxicology, whereas Chapter 7 discusses the smuggling of plants or their products, including illicit drugs and protected plants species such as orchids and pitcher plants. Chapter 7 includes a significant discussion on the illegal trade of lumber and other products from protected trees. These chapters were interesting on their own but felt to me like a bit of a departure from the main themes of the rest of the book. The final section of this book discusses the importance of training new botanists who have the expertise to contribute to the analysis of botanical forensic evidence.

Helpfully, the book also includes endnotes for each chapter, which facilitates further reading if desired. It also includes five glossy color plates, a general index, a species index, and a glossary for terminology related to forensic methods, including many techniques used in molecular biology.

I enjoyed this book and feel like learned a considerable amount. As an avid watcher of the TV show *Forensic Files*, I was eager to read about cases involving botanical evidence and I was not disappointed. The example cases are described in enough detail to be interesting and so that the reader can understand the concepts presented but are in no way sensationalized. A particular strength of this book is the way that important botanical concepts in areas such plant anatomy and life history are conveyed in an approachable way. This book would serve as an excellent reference text for preparing a lecture or a classroom activity on forensic botany. It is a fascinating read for anyone interested in botany, forensic science, or true crime.

-Mackenzie Taylor, Department of Biology, Creighton University, Omaha, Nebraska USA

Putting Down Roots: Foundations of Botany at Carolina with a Concluding Chapter on the History of the Department of Botany



Burk, William R.
2023. ISBN: 978-1-889878-71-3
(Flex) US$54.00; 615 pp.
Sida, Bot. Misc. 62. Botanical Research Institute of Texas, Fort Worth, Texas.

Chartered in 1789, it wasn't until 1792 that a committee of the Board of Trustees suggested a curriculum for the new University of North Carolina. Among other recommendations was: "Information in Botany to which should be added a competent knowledge in the theory and practice of Agriculture, but suited to the climate and Soils of the State" (p. 1). For the next century, a series of eight men gave lectures or courses on botany in a one-man department. These men are the primary focus of the book with a chapter dedicated to each. The first two were Yale-men and William Burk provides a brief section on the Yale professors and their influence on their Carolina proteges. Similarly, there is a brief section on Cornell and its influence on the three alums who introduced and developed laboratory instruction in botany at Carolina. Burk also introduces several educational enhancements for botanical instruction: the library, the university museum, the laboratory the Normal School/Summer School, and the Elisha Mitchell Scientific Society. Individual contributions to each of these is included in subsequent chapters. Each chapter is an extensive mini-biography including: family background; educational training; moving to Chapel Hill, including housing information and costs; how and what courses were taught; university and public service; and post-Carolina experience.

The first documented botany class taught at Carolina was in Denison Olmstead's Chemistry class and focused on light responses of plants. Olmstead taught Chemistry and Geology from 1819 to 1825. Some of the light effects studied included etiolation and greening, cycling of carbonic acid and oxygen in photosynthesis, and the role of light in plant growth. Certain plant products were also covered: starch, gums, resins, oils, tannin, and pigments. Olmstead left in 1825 to return to Yale.

Elisha Mitchell, a fellow student at Yale, was hired to teach Mathematics at the same time as Olmstead. When Olmstead left, Mitchell replaced him as Professor of Chemistry and Geology. Mitchell devoted the next 30 years to developing the Natural History program at Chapel Hill and in 1840 self-published a textbook of natural history for students to use. The first documentation of Mitchell's including botany in his lectures was in 1838, but in his text, he noted, "As part of a liberal education, the study of Botany is to be defended chiefly on the ground that is affords an excellent exercise to the mental powers, generates habits of accurate observation and furnishes a source of elegant and innocent recreation and amusement" (p. 96). Mitchell's passion for geology cost him his life in 1857 when he fell over what is now Mitchell Falls, on a geological trip to ascertain the height of today's Mount Mitchell, the highest peak of the Appalachian Mountains.

John Kimberly, a New Yorker with ties to both Yale and Harvard, replaced Mitchell as Professor of Chemistry Applied to Agriculture and the Arts. After completing his BA in 1837, he moved to Raleigh, NC and studied law, but chose to teach at an academy for Black children until 1855 when he moved to Nashville. Returning to Carolina after Mitchell's death, he taught at the school throughout the Civil War and until the school was closed and reorganized in 1868 at the beginning of reconstruction. Following this reorganization, a Quaker immigrant from England, George Dixon, was hired from the local freedman's school in 1869 to fill a newly created Professorship of Agriculture. The society writer from a local paper, Cornelia Spencer, called him "as green a specimen of a fresh-caught John Bull … more ignorant of the people he had come among than semi-educated Englishmen usually are." He lasted a year before moving to the Hampton Institute in Virginia where he taught for 13 years.

Kimberly returned for one year before being replace by William Henry Smith, who also served for a single year. The reorganized College of Natural History had four schools, one of which was Botany. Smith, the first professor to hold a doctorate at the time of his hiring, was responsible for botany. Trained at Michigan, he was a proponent of active learning: "book knowledge, however good, when compared to an examination of the object is like the dry bones in the prophet's vision" (p. 249). An accusation of having an inappropriate interracial relationship with a Black cook led to his resignation. In a letter to the President, Smith "stated that the accusation against him would have been different had he been a southerner" (p. 255).

Frederic Simonds, the first of the Cornell graduates, was professor of botany from 1877 to 1881 and taught the first full botany courses at Chapel Hill. Simonds quickly became known for his enthusiastic lecturing and artistic drawings, done in color and with both hands. Lecture notebooks of three students, along with newspaper articles describing his teaching, are archived. Simonds was also the only science faculty member to present talks and/or lectures in the Normal School, a 5- to 6-week summer school for teachers and prospective teachers that operated from 1877 to 1884. A disruptive classroom incident in 1881 apparently led to his resignation when he said something to the effect of "were they little boys or gentlemen?" According to Cornelia Spencer, this was taken by some students as an accusation of not being gentlemen "(that name so dear to southern ears & so little understood in truth by many who claim it)," which made the matter worse. This confirmed her impression that Simonds was "too much a Yankee to teach successfully in the South" (p. 287).

Simonds replacement, Joseph Holmes, was also a Cornell grad, but hailed from South Carolina. A colleague noted: "Finally, as he [was] a Southern man and ambitious to advance the interest of the south he [would] be more devoted to his work with you than a man from the North (p. 304). Holmes held dual appointments in Geology and Botany and for several years the school of botany grew with continued emphasis on laboratory, with microscopes, and field instruction but in 1885 the legislature established a new Agricultural and Mechanical college in Raleigh funded by cuts to the Chapel Hill campus. In 1891 Holmes suggested that Natural History be divided into the Departments of Biology and Geology, with the former department being approved that year. Holmes resigned and was invited to become State Geologist.

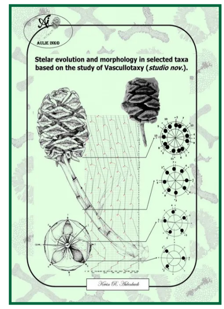
The biologist hired to replace Holmes was Henry van Peters Wilson, a zoologist trained at Johns Hopkins with extensive post-doctoral training in marine biology. He served as a one-man department until 1902 when funds were made available to hire an Associate Professor of Botany, William Chambers Coker. Peters Wilson also oversaw the transition of the Normal School to a Summer School in 1894. The summer school, which ran from 1894 to 1901, served the same students, but offered more formal coursework and was stronger in the sciences. Six of those eight years focused on botany with invited summer lecturers. Burk provides a brief chapter on each of these lecturers: Dixie Lee Bryant, the first woman to teach botany at UNC; Austin Craig Apgar (twice); Wilbur Samuel Jackman; Robert Ervin Coker; and George Francis Atkinson. Atkinson, the third Cornell graduate, was actually a faculty member teaching zoology in the Natural History Department and Zoologist in the College of Agriculture from 1885 to 1888, but was a victim of retrenchment with the founding of the A&M College in Raleigh. Burk notes that after Carolina, Atkinson had an extremely successful career at Cornell, and was a founding member, and first President, of the Botanical Society of America.

In 1908 the Biology Department was split into the Departments of Botany and Zoology; Coker became chair and was promoted to Professor. The final chapter is a brief history of the Department from its founding until the two departments reunited in 1982 to once again become a Biology Department. The chapter is organized by the administration of the subsequent chairs: Coker, 1908–1944; John N. Couch, 1944–1960; Victor A. Greulach, 1960–1972; and Tom K. Scott, 1972–1982. It is clear from the presentation that the focus of the Department was always on graduate study and research, and they were very successful in this regard. In the mid 1960s, UNC's Botany Graduate Program was ranked among the top 3 programs in the South and top 16 in the country.

Putting Down Roots is not a casual read, but it is detailed and well documented. Burk does an excellent job of providing the historical and social context, particularly sectional biases, to explain the challenges and opportunities provided to each of the "founders" of Carolina Botany he describes. He makes good use of chronological tables to provide a map of milestones leading to formation of the Department (Table 1.1) and key events in the history of the Department (Table 15.1). The book is well-illustrated throughout with portraits, landscapes, infrastructure, and key documents. Each chapter has an extensive list of references cited. Several chapters have informative appendices. I particularly liked the transcription of 15 pages of a student's botanical notes from his 1820 chemistry notebook (Appendix 2.1) and 7 pages of Mitchell's lecture notes on botany from 1840 (Appendix 3.2). There are extensive indices of subject (including individual's names) and Scientific and Common names.

The one area that leaves questions for me involves the departments merger in 1982. Already in 1969, Gruelach noted that several zoologists were pushing for a unified biology department (p. 493). In 1981 the Department learned that higher administration "made a preliminary decision to recommend consolidation" followed by a report by a "Committee to Study Creation" of a merged department that raised "strong reservations and opposition" especially by the botanists (p. 498). But this was apparently preceded, in 1980, by an external graduate program review that stated forcefully "Department in-fighting must be terminated" and "Internal problems seem to have caused the faculty to lose sight of these [within the university] roles" (p. 500). What was the basis of this in-fighting and how was it perceived by administration? Were the zoologists and administrators the "bad guys" or did the botanists "shoot themselves in the foot"? This book will be of interest to American historians, historians of science, and those interested in the history of UNC.

--Marshall D. Sundberg, Professor Emeritus, Emporia State University, Emporia, KS.



Stelar Evolution and Morphology In Selected Taxa Based On The Study Of Vascullotaxy (Studio Nov.) (ed2)

Kevin R. Aulenback
2022. ISBN: 978-0-9812186-5-6.
US$149.95; 264 pp.
Aulie Ink, Drumheller, Alberta, Canada

In the first edition of this book, Aulenback developed and introduced a new concept of vascullotaxy, the regular and predictable pattern of primary xylem in the axis of vascular plants (Sundberg, 2020). He then used this anatomical framework to hypothesize on stelar evolution and the origin of various morphological structures such as microphylls, megaphylls, branching, and reproductive structures. About half of the topics are identical between the two editions, but many new taxa are added in this edition and there is considerable elaboration on topics related to how morphology may be influenced by underlying vascular development.

Vasculotaxy is based on the founding hypothesis that all stele types are based on a sequence of sympodia arising in an ascending helix. The section "Variables and laws of sympodial behavior" explains the principles and application of vasculotaxy in which the number of sympodia increases (or decreases) through successive Fibonacci series in a helical progression to produce the various stele types.

(See Sundberg [2020] for more elaboration.) This mechanism for stelar evolution and development is novel and significant.

An important addition to the critical terminology section at the beginning of the book is a definition of stele, the root of the first word of the title. The author's definition is important because in addition to the commonly accepted definition of the pattern of procambial derivatives at the center of an axis, it also includes "radially aligned proto/metaxylem [= secondary xylem]…." Consequently, cambial growth is not recognized as distinct from primary growth, and this makes untenable one of his critical criteria for defining megaphylls (primary "sympodial traces travelling through both disorganized proto/metaxylem (Polypodiidae, Cladoxylopsida) or radially aligned proto/metaxylem (Medullosans, protogymnosperm/angiosperm)." It also forces him to specifically reject recent evo-devo explanations of stele development with a role for endodermis in the control of cellular differentiation in the stele (Tomescu, 2021). Nevertheless, AuIenback rightly notes that commonly used traditional botanical terms, especially those based on morphology, are not appropriate for this type of anatomical study and that new terminology is required. For instance, definitions of internode and node are added to this edition, primarily to justify the phrase "helical group of" as a replacement for the usual morphological terms of opposite or whorled when more than one appendage appears to arise at the same node.

The best example of such "helical groups" is found in the sphenophylls, including extant Equisetum, taxa newly added to this edition. The author's vasculotaxy explains both the general patterns and variations observed by Bierhorst (1959) in his study of vascular symmetry in Equisetum. Aulenback's diagram of helical groupings at nodes (Fig. 40) interprets the morphologically distinct "node" as a series of highly compressed nodes and internodes each consisting of a single sympodium and its departing trace. This interpretation is remarkably similar to the sympodial arrangement of procambium in the nodal plexus of maize (Pizzolato and Sundberg, 2001) but with individual sympodia supplying microphylls rather than multiple sympodia supplying a single megaphyll. Given this assumption, nodes that appear to have opposite or whorled appendages are interpreted as a collection of very compressed nodes. Even SEM organographic studies of whorled apices often show at least hints of asynchrony (Rutishauser, 1999), so this is not as radical an interpretation as it might initially seem. Unfortunately, the interpretation of axillary buds at Equisetum nodes is not as convincing.

The section on the "Evolution of the lateral bud: branch stems, microphylls, megaphylls and bud stems" is significantly expanded with a sub-section for each category, but some of the same problems noted for the first edition have not been adequately addressed. It is still not clear why stem branching of a plant in the 0/1 series (a traditional haplostele) is not a dichotomy, but must be a pseudodichotomy? It also remains unclear how the multiple sympodial traces supplying a megaphyll can be differentiated from those supplying a bud. The argument of attracting radially aligned proto/metaxylem [secondary xylem] still ignores the ontogenetic progression of procambium – protoxylem – metacambium – metaxylem - vascular cambium - secondary xylem demonstrated by Larson (1983).

By far, most of the new information involves the addition of many more fossil groups to the analysis. In addition to the sphenophylls mentioned above, other new taxa examined in this edition include: a variety of ferns, seed ferns, and several new angiosperms, including Amborella, Arabidopsis, and an extensive examination of Hippeastrum. Some floral generalizations are that perianth parts are megaphylls, but not a part of the flower, per se, and that the reproductive structures, both stamens and carpels are derived branch stems. The main problem with this book is that the author's interpretation of morphological evolution is based on rigid anatomical rules that do not reflect well-documented ontogenetic constraints and phenotypic plasticity.

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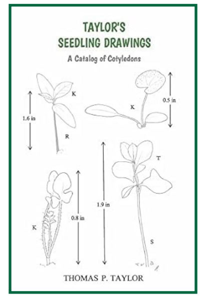
-Marshall D. Sundberg. Kansas University Affiliate and Roe R. Cross Professor - Emeritus, Emporia State University, Kansas.

Taylor's Seedling Drawings: A Catalog of Cotyledons



Taylor, Thomas P.
2022. ISBN: 979-8-218-05180-8
US$16.95 (Paper); 208 pp.
Self published

For many a botanical researcher or casual gardener, identifying seedlings can be a difficult challenge. Experiments often involve controlling the number and types of seedlings in the field or greenhouse and plucking the undesirables. Even for the casual gardener growing plants from seeds, it is useful to distinguish weeds from target plants. Identifying adult plants has been greatly simplified by "apps" like iNaturalist, PlantNet, or PictureThis, but identifying seedlings is a more complex task. In some cases, like for tallgrass prairie restorations, seedling identification is crucial for properly managing the landscape.

Thomas Taylor's *Taylor's Seedling Drawings* addresses this problem with drawings of seedlings in "a catalog of cotyledons," containing renderings of 190 different species, presented alphabetically by plant family name. The species span both native and cultivated plants, including herbaceous and woody plants, growing in eastern North America. I was interested to see several species included, like lamb's quarters, jimsonweed, prostrate spurge, and tree of heaven, which are frequent, weedy species in my region.

While the bulk of the book (189 pp.) contains the plant drawings, Taylor provides a six-page introduction where he discusses his own background as a gardener and some general hints on seed germination, such as the need for stratification or scarification. He does not specify the germination requirements for each species, just general recommendations like "most plants from the temperate zone will need to be stratified." Readers wanting more specific recommendations would do well to consult works like the classic *Collecting, Processing and Germinating Seeds of Wildland Plants* by Young and Young. Taylor also details the methods he undertook to grow the seedlings and produce the drawings, with details on light conditions and sketching and digitizing techniques.

The drawings themselves are black and white, freehand sketches, with minimal shading; thus, they are not very technical or realistic. It appears that the goal was to represent some "key" characteristics of species rather than present a "photo-like," 3-D, realistic rendering. For instance, the drawing for prostrate spurge is good for leaf margins, size, and number, but does not give an accurate sense of the 3-D structure of the leaf and stem arrangement. In other words, these drawings appear quite simple and two-dimensional. Stem height measurements are included, and colors are indicated with the help of a color code printed on the back cover.

Now the important question: would this guide work? Suppose I had a student doing a "seed bank" study where they collected soil from a nearby prairie and wanted to identify the early seedlings. Here, I can't say that I'm certain the guide would always work. A problem I can imagine would occur is the fact that the size, color, and shape of seedlings can vary with environment. Taylor does acknowledge that "a plant growing under intense sunlight does not obtain the same proportions as the same plant born in the shade" and addresses the issue by clearly specifying the conditions under which he produced the drawings, so at least that can be replicated.

Leaving aside the issue of whether the guide consistently allows accurate seedling identification, I believe this guide could add to a library of useful references on the bookshelves of seedling aficionados. The prairie restoration literature is replete with plant guides, although some like *Prairie Seedlings Illustrated: An Identification Guide* by Dittmer and Jackson are booklets that can only be acquired from the authors. In my experience teaching botany, overseeing student projects, and growing my own seedlings, you can't have too many plant guides, especially for seedlings. And I say this as an enthusiastic user of plant apps on my phone! There is always a project involving close observation of growing plants, and the more drawings and descriptions you have of your subject of interest, the better.

I admit, I miss the days of biology lab where we were tasked with careful drawings of specimens. There was something so thorough and satisfying about producing those drawings, as if one had communed with the life form in question. I'm gratified that there are people in the world who still do this and provide the fruits of their labor for others to use and enjoy. Thus, I'm happy to have Taylor's book on my shelf, where it joins other good seedling references like the two mentioned above.

--Mary Ann Vinton, Ph.D., Professor, Department of Biology, Director, Environmental Science Program, Creighton University, Omaha, Nebraska

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The Botanical Society of America is a membership society whose mission is to: promote botany, the field of basic science dealing with the study & inquiry into the form, function, development, diversity, reproduction, evolution, & uses of plants & their interactions within the biosphere.

Curious about the Conference Logo?

A lot of thought goes into the Botany Conference logo each year. The logo for *Botany 2024 – Resilience in a Changing World* was informed by our desire to select plants that are native to Michigan and exemplify resilience in various ways.

Arnica cordifolia Hook. - Heartleaf Arnica:
The showcased plant is *Arnica cordifolia* Hook., the heartleaf arnica. A member of the Asteraceae, this perennial species is endangered in Michigan but thrives across western and northern North America. Known for its adaptability to both shade and sun, moderate fire resistance, and a potential need for disturbance in order to be successful, the heartleaf arnica has a long history of medicinal use.

Zizia aptera (A.Gray) Fernald - Prairie Golden Alexanders:
The plant with yellow-flowers in flat-topped umbels is *Zizia aptera* (A.Gray) Fernald, also known as Prairie golden alexanders, Heartleaf golden alexanders, or Meadow zizia. While this species in the Apiaceae is threatened at the state level, it maintains globally security as a short-lived perennial, relying on re-seeding for its persistence.

Cypripedium parviflorum Salisb. - Yellow Lady's Slipper:
The yellow lady's slipper, *Cypripedium parviflorum* Salisb., is a familiar orchid that is widespread across North America with several varieties commonly recognized. The yellow lady's slipper is globally secure with a conservation status of least-concern.

Woodwardia areolata (L.) T. Moore - Netted Chain Fern:
In the background of the logo is the beautiful *Woodwardia areolata* (L.) T. Moore (= *Lorinseria areolata* (L.) C.Presl), the netted chain fern. Native to the southeastern United States, this globally secure member of the Blechnaceae ranges northward along the eastern coast and has a historical presence in Michigan, last seen in Van Buren county (southwest of Grand Rapids) in 1880. Although it hasn't been seen in Michigan for over a century, it is presumed to be present, so keep a keen eye while enjoying any conference field trips—and document any sightings with photos—as the rediscovery of this species during our conference botanizing would be a remarkable event.

Conference logo designed by Melanie Link-Perez and Johanne Stogran